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# Iron AND Steel ENGINEER

ENGINEERING SERVICE
TO THE IRON AND STEEL
INDUSTRY SINCE 1907

JULY • 1943

## Long may it wave

We pledge allegiance to the Flag of the United States of America, and to the Republic for which it stands; one Nation, indivisible, with liberty and justice for all.

WEAN

**Associated Companies**

LEE WILSON ENGINEERING CO., INC.
CLEVELAND, O.

THE McKAY MACHINE CO.
YOUNGSTOWN, O.

FLINN & DREFFEIN CO.
CHICAGO, ILL.

THE WELLMAN SMITH OWEN ENGR. CORP., LTD.
LONDON, ENGLAND

THE HALLDEN MACHINE CO.
THOMASTON, CONN.

THE WEAN ENGINEERING CO. OF CANADA, LTD.
HAMILTON, ONT.

R
v. 20 2
July-Dec 1943

# A BOON TO AMERICAN INDUSTRY

## NEW CUTLER-HAMMER CONTROL FOR PERFECT CRANE PERFORMANCE ON *Alternating Current*

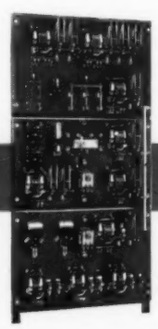
LONG sought and now imperative, perfect crane performance on *alternating current* is now an established *fact*. The new Cutler-Hammer AC Crane Control provides full dynamic lowering over a complete range of 5 stable speeds . . . accurate inching for spotting loads, setting slings, etc. . . . and unvarying response . . . on alternating current.

No need to install expensive direct current generating equipment or rectifiers. No more clumsy, costly makeshift load brakes. This new C-H AC Control handles loads so much like DC, that operators can't tell the difference, and it enables them to get the maximum production from their equipment.

You should insist on this outstanding engineering advance for your next crane. There is nothing like it. Write or wire *today* for full information.

CUTLER-HAMMER, Inc., 1269 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.

Control engineering ingenuity solved the long standing problem of how to get Crane performance on alternating current. This control panel of standard C-H units does the job with a standard AC motor.



Copyright 1943—Cutler-Hammer, Inc.

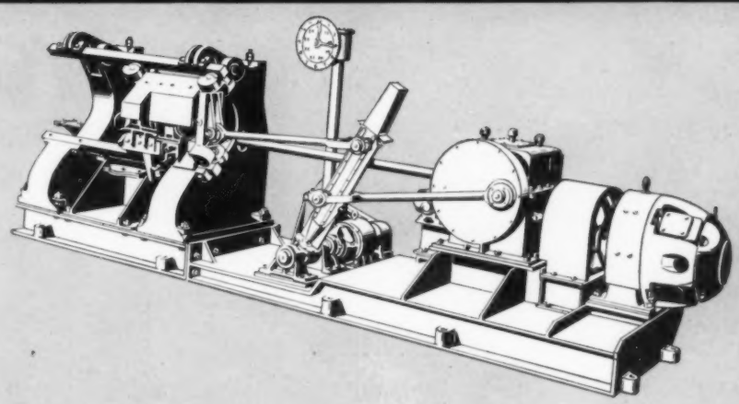
CUTLER-HAMMER
MOTOR CONTROL
C-H

Tech.

SYMBOLS OF FREEDOM

# FREE ENTERPRISE-
## DEMOCRACY'S SECRET WEAPON

Labor, management and capital, working together have given this country a higher standard of living than anywhere else in the world. This same team now produces the tools for victory in greater quantity than the Axis ever dreamed possible and finally, when the post-war reconstruction period arrives Free Enterprise will again prove its value and efficiency.



**AETNA FLYING HOT SAW** cuts continuous butt-welded pipe in sizes from one-half to four inch diameter with tolerances of plus or minus one-quarter inch at speeds up to five hundred feet per minute.

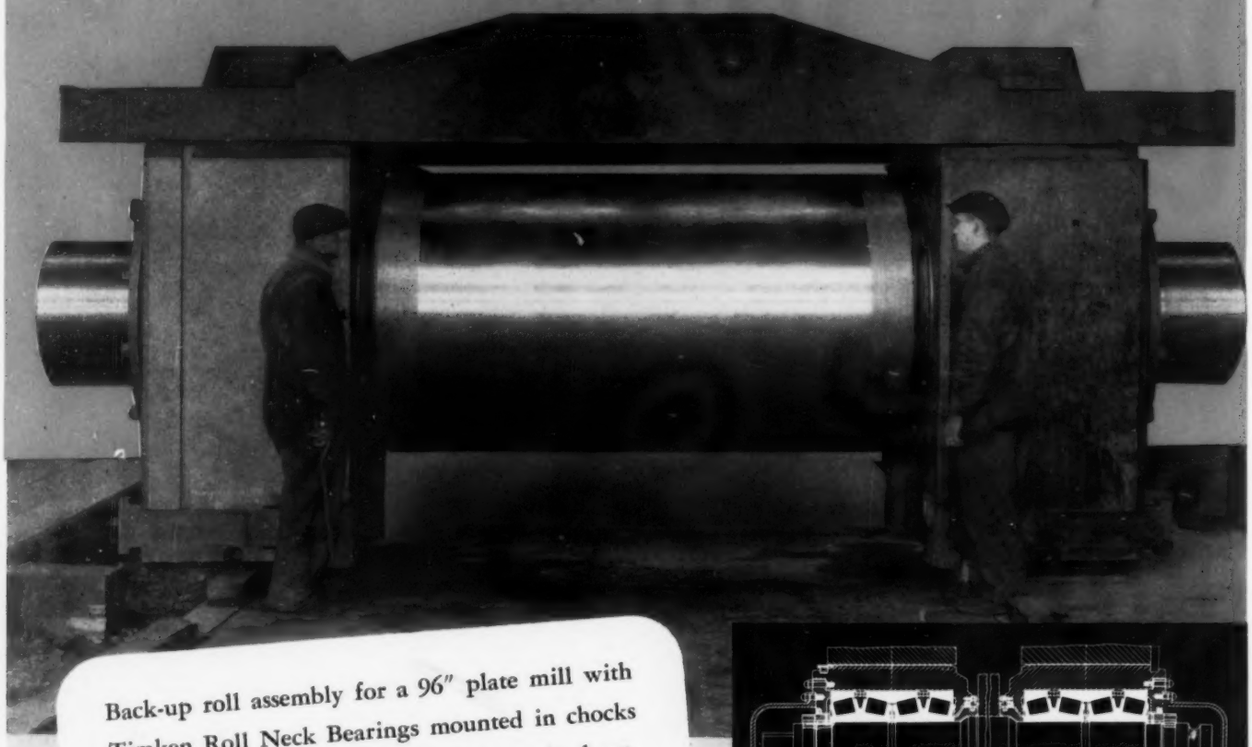
ARMY E NAVY

The AETNA-STANDARD
ENGINEERING COMPANY
YOUNGSTOWN, OHIO, U.S.A.

*ASSOCIATED COMPANIES*
HEAD, WRIGHTSON & COMPANY, LIMITED, THORNABY-ON-TEES, ENGLAND •
JOHN INGLIS COMPANY, LIMITED, TORONTO, ONTARIO, CANADA

*Designers and Builders to the Steel, Non-ferrous and Chemical Industries*

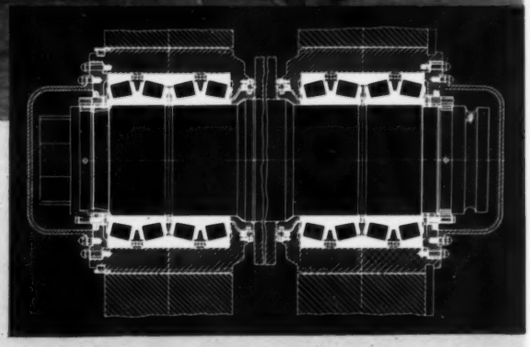
# READY FOR A *Long Life* OF EFFICIENT, ECONOMICAL ROLLING SERVICE



Back-up roll assembly for a 96" plate mill with Timken Roll Neck Bearings mounted in chocks at both ends ready for installation in the housing. Self-contained, simple, compact; makes roll changing easy; no complicated or delicate parts to handle; positive lubrication; chocks effectively sealed against leakage of lubricant or entrance of foreign matter.

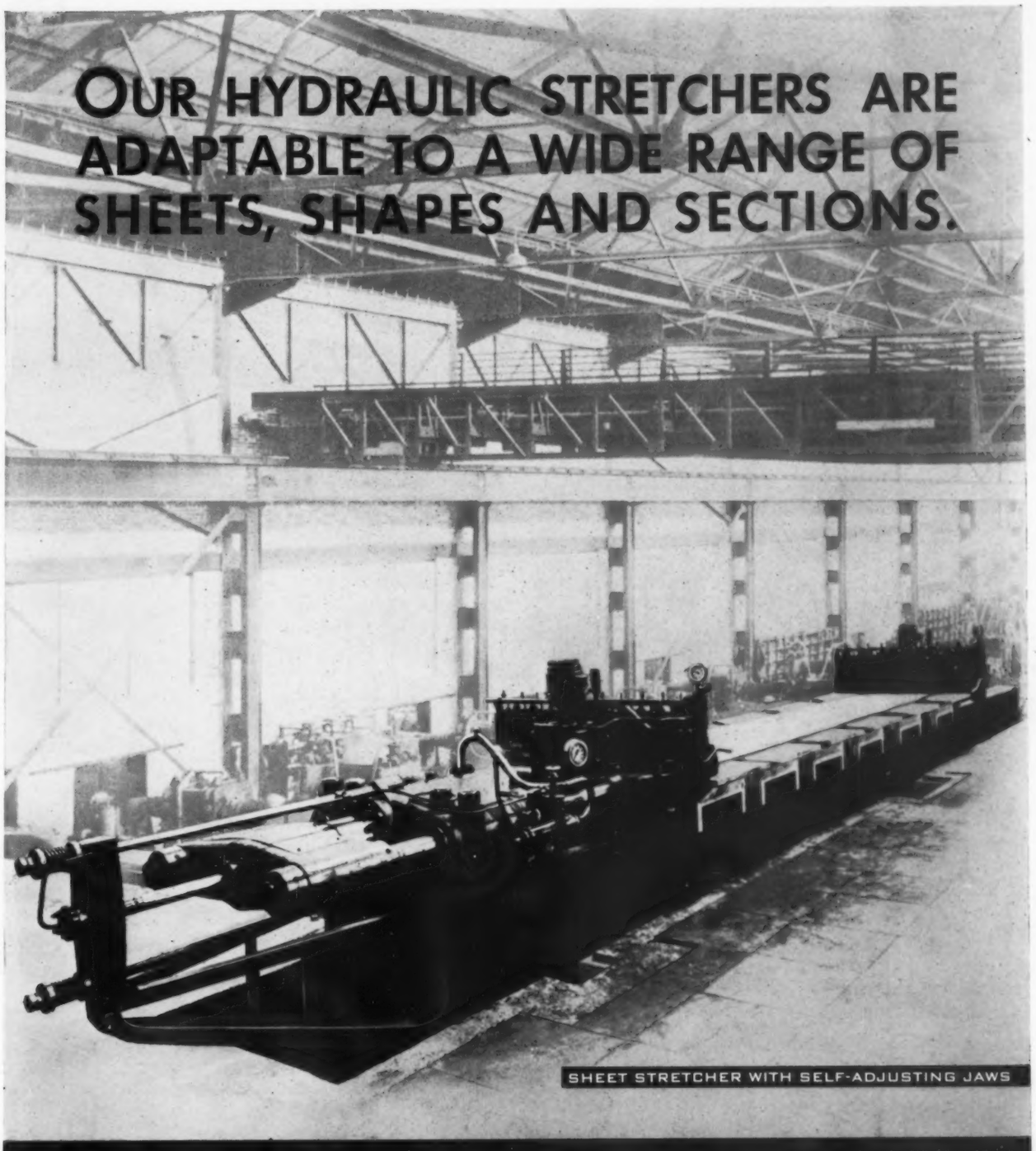
Timken Roll Neck Bearings in mountings similar to this have rolled the highest tonnages ever rolled by any roller bearings used on mill roll necks—*upwards of eight million tons*—at the lowest bearing cost per ton rolled ever recorded. The Timken Roller Bearing Company, Canton, Ohio.

TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
TAPERED ROLLER BEARINGS



Typical Timken 4-row back-up roll neck bearing mounting similar to the mounting used in the roll assembly shown above.

**Put Timken Bearings in existing mills to help bring Victory closer; put them in new mills to meet the competitive challenge of the future.**

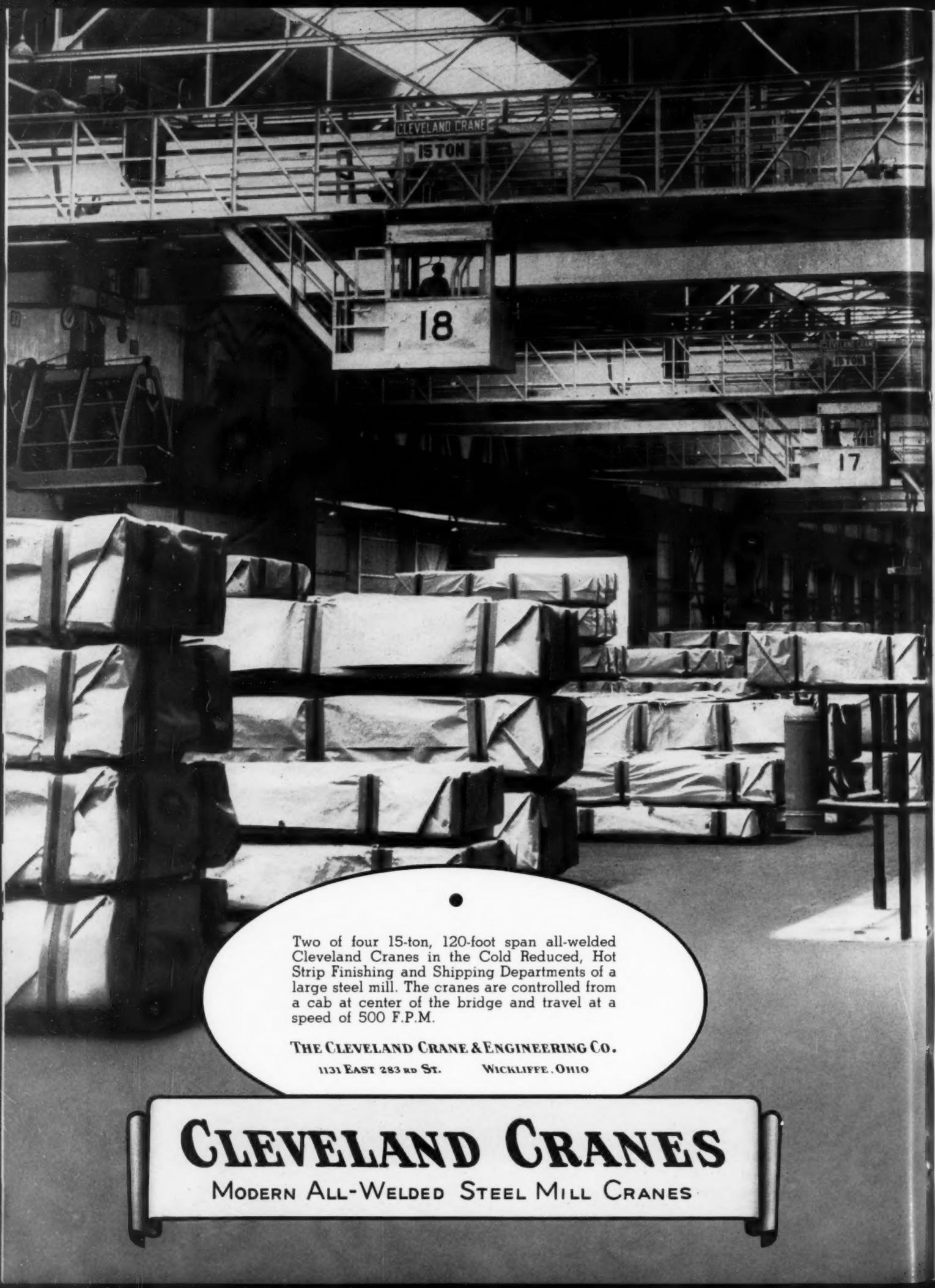

OUR HYDRAULIC STRETCHERS ARE ADAPTABLE TO A WIDE RANGE OF SHEETS, SHAPES AND SECTIONS.
SHEET STRETCHER WITH SELF-ADJUSTING JAWS

HYDROPRESS · INC.

ENGINEERS CONTRACTORS

HYDRAULIC PRESSES · ROLLING MILLS
PUMPS · ACCUMULATORS

570 LEXINGTON AVENUE · NEW YORK · N. Y.




Two of four 15-ton, 120-foot span all-welded Cleveland Cranes in the Cold Reduced, Hot Strip Finishing and Shipping Departments of a large steel mill. The cranes are controlled from a cab at center of the bridge and travel at a speed of 500 F.P.M.

THE CLEVELAND CRANE & ENGINEERING CO.

1131 EAST 283 RD ST. WICKLIFFE, OHIO

# CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

# Crops *and* Shorts

INCREASED consumption and inclement weather at the start of the navigation season have combined to reduce iron ore stocks at the lower end of the Lakes almost 4,000,000 tons below the same period last year. Lake ore consumption is now approaching 7,400,000 tons. Last summer the ore fleet hauled 12,500,000 — 13,500,000 tons per month, and with the new large carriers in service this summer, it is expected to haul 14,000,000 tons in a month. The Irving S. Olds recently brought down an 18,161 ton record cargo of ore, and the Benjamin F. Fairless carried 18,022 tons. It is doubtful if soundings around Sault Ste Marie locks will permit larger cargoes. However, steel executives believe no trouble will be experienced in bringing down the year's requirements.

Incidentally, the same executives asserted that the Lake ore reserves will last out "our lifetime," and foresaw no possibility of exhaustion.

▲

FIGURES recently released show an overall average monthly income of $85.03 in April, 1943, as compared to $47.92 in July, 1940. We'll bet that most of our readers would settle for half of that rate of increase.

▲

WHILE labor, management and government meet in entente cordiale to try to boost steel production by 2,000,000 tons in the last quarter, the coal strike merrily clips tonnage off at an even higher rate. Looks as though the three-point "Steel for Victory" drive should include an obvious fourth point.

▲

NOTWITHSTANDING the steel lost because of the out-of-hand coal situation, the nation's mills produced a record-breaking tonnage of ingots and castings in the first half of the year. Production reports show a total of 43,866,912 net tons. June production slumped to 7,027,101 tons, compared to 7,545,379 tons in May and 7,015,302 tons in June last year. These first half figures indicate a back-breaking job for the industry in the laft half if the desired goals are to be approached.

▲

ALL previous complaints pale into insignificance as critical shortages hit bottom with a reported shortage of diapers and safety pins, according to Representative Frances P. Bolton of Ohio.

WHEN you see plant property deliberately destroyed, windows deliberately smashed, and a hundred other items of hoodlumism perpetrated by workers in plants, you can't help wondering why these same pamered hooligans feel entitled to a voice in management. Personally, we long for the return of the "bull of the woods" who ran his shop with an iron but human hand.

▲

NOW that we've seen a strike of foremen in a Detroit manufacturing plant, we've seen everything. It is the accepted belief that a supervisor must be a "company man," and so he must be for the good of the company and of the individual. Yet in many cases, he is becoming the "forgotten man" — and he isn't happy about it. Here are a few of the complaints we've heard:

Wage and salary raises for all — except superintendents.

Extra pay for vacations not taken by employes — except superintendents.

Removal from payrolls during strikes.

Demotion to watchmen, with watchman pay, during depressions.

Dictatorial management, with little initiative allowed the superintendent.

A tendency to by-pass the superintendent in employe-management relations.

And so the list goes — complaints indicating an unhealthy condition that should not be allowed to spread.

▲

THE increase in ash content in blast furnace coke in the first 10 months of 1942 cost us production equivalent to the output of two large blast furnaces, according to the Bureau of Mines in the Report of Investigation 3711, "Increased Pig Iron Output Through Improved Coke." First results of a committee working on this project, the report enumerates five major problems limiting iron production: limited supplies of preferred coking coals, increasing ash and sulphur content of coals, non-uniformity of coke, poor quality of coal for beehive ovens, and difficulties in obtaining and maintaining equipment. Certain operating details from efficient plants are mentioned, including careful control of coal crushing, control of coke bulk density by addition of oil or water, increased use of low volatile coals, automatic quenching, more careful sizing of coke, with efficient screening and separate charging of wet coke into the furnace.

▲

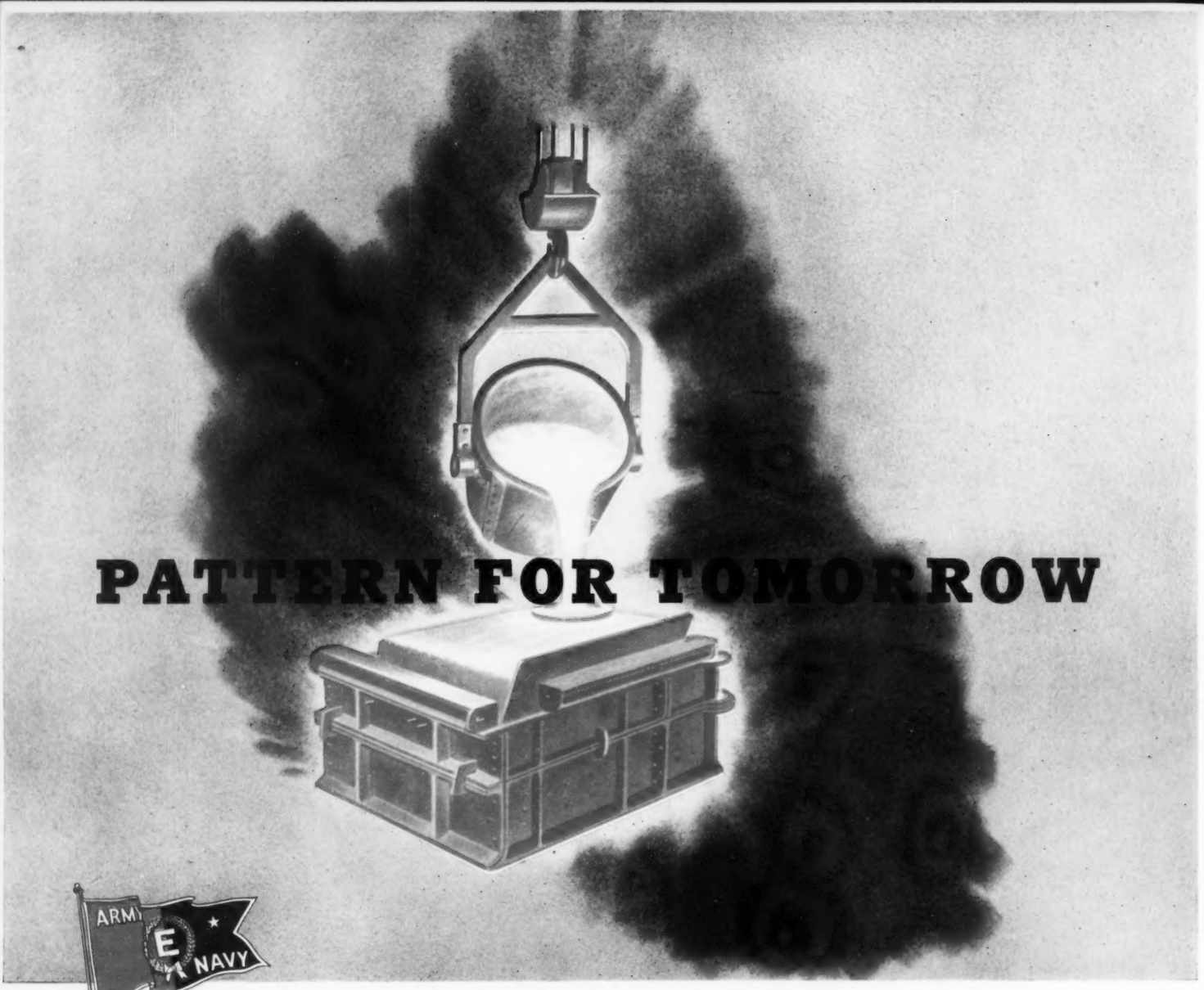
MOST of the surveys on post-war activity predict ten years of plenty following the close of the present hostilities, based principally upon the pent-up demand for consumer goods. One report even looks for a large volume of plant construction in such industries as food products, paper and pulp, printing and publishing, ceramic products, textiles, refrigerators and cold storage, lumber and woodworking, leather and leatherworking, railroad shops, etc. Considerable replacement of industrial equipment is forecast because of rapid wear and scant maintenance during the present production drive.

From reading many of the advertisements now appearing, we look for a utopian paradise wherein work is almost abolished and all of our present possessions are rendered obsolete through miraculous improvements which cannot be revealed now for reasons of military secrecy.

UNITED
BLOOMING AND
SLABBING MILLS
ALL TYPES, ALL SIZES
INCLUDING
THE WORLD'S LARGEST

**UNITED ENGINEERING *and* FOUNDRY COMPANY**

Pittsburgh, Pennsylvania, U. S. A.




TOMORROW is cast in the furnace of today—and not all the wisdom of the sages can make a good product from a poor pattern, nor sound material from an unsound melt.

★ ★ ★

In all its years, Union has projected into its castings the soundness of its metallurgical knowledge, the "know-how" of its pattern-making, understanding of the stresses of use. Union's men of science have always had Tomorrow in mind.

★ ★ ★

The men of Union had Tomorrow in mind when they pioneered that new, tough steel called "Univan" . . . the Web-Spoke driving wheel center for locomotives . . . the amazing new-day method of combining cast and fabricated parts known as "Fabricasting."

★ ★ ★

Even today, all-out for Victory, these men have the pattern of Tomorrow very much in mind. Though they may not be able to supply you promptly with goods until "unconditional surrender," they can and will think and plan with you—for your *better* products and *greater* profits.

## UNION STEEL CASTINGS

**DIVISION OF BLAW-KNOX COMPANY • PITTSBURGH, PENNSYLVANIA**

**MAKERS OF:**

***Driving wheel centers, locomotive frames, pump casings, vault doors and frames, annealing boxes, spindles, coupling boxes, open hearth charging boxes, gear blanks—and other steel and alloy castings for steel mills and general industry.***

# HOW TO HELP "keep 'em firing" in your ELECTRICAL CONTROL army

It is DOUBLY important now to have some person in your plant definitely responsible for constant watch over electrical control apparatus. First, because the war effort must go on—without serious production delays. Second, because critical materials must be preserved—they are increasingly hard to replace . . . These fundamental inspection and maintenance pointers are available in printed card form. Write us for a supply. Post them where they may be useful.

## INSPECTION

**1.** OVERLOAD? Check present installations to make sure increasing demands have not stepped up loads beyond the danger point.

**2.** PROTECTED? Check condition of fuses—heaters—circuit breakers. Make sure ratings are correct for present load carried.

**3.** WEAR? Check individual switch and control units for condition of contacts, wear of parts, freedom from dust and dirt.

**4.** SAFETY? Check condition of switch and control boxes—make sure interlocking safety devices are in operation and are being properly used. Replace faulty gaskets (on gasketed type enclosures). Be sure that the equipment is adequate to handle the requirements of the job.

**5.** OVERHEATING? Check location and load conditions of apparatus. Relocate where excessive ambient temperatures may cause trouble.

**Be sure the circuit is dead before working on current carrying parts.**

## MAINTENANCE

**1.** OPERATE ALL SWITCHES AND CONTROLS PERIODICALLY. Allow none to become "forgotten".

**2.** CLEAN or "BLOW OFF" all apparatus—especially that in dusty or hazardous locations.

**3.** LUBRICATE REGULARLY and carefully, to prevent friction and wear and tear—do not over-lubricate.

**4.** REPLACE (promptly) PARTS that may be worn or imperfect—a minor part replaced may save major trouble.

**5.** CHECK WIRING CONNECTIONS FOR TIGHTNESS at all points of contact — terminal lugs, fuse contacts, etc. Keep screws tight.

**6.** CLEAN CONTACTS in accordance with instructions on inside covers and check for burning, pitting, and for proper alignment.

**7.** TEST handles, crossbars, blades, for correct engagement, alignment and operation.

**8.** PAINT boxes, conduits, etc. periodically to prevent rust or corrosion.

**9.** TAKE CARE of your maintenance before repairs are necessary.

**NOTE:** TRUMBULL apparatus is readily inspectable and, to a large extent, parts are replaceable *from the front*. Details of design make inspection and maintenance easier.

TRUMBULL

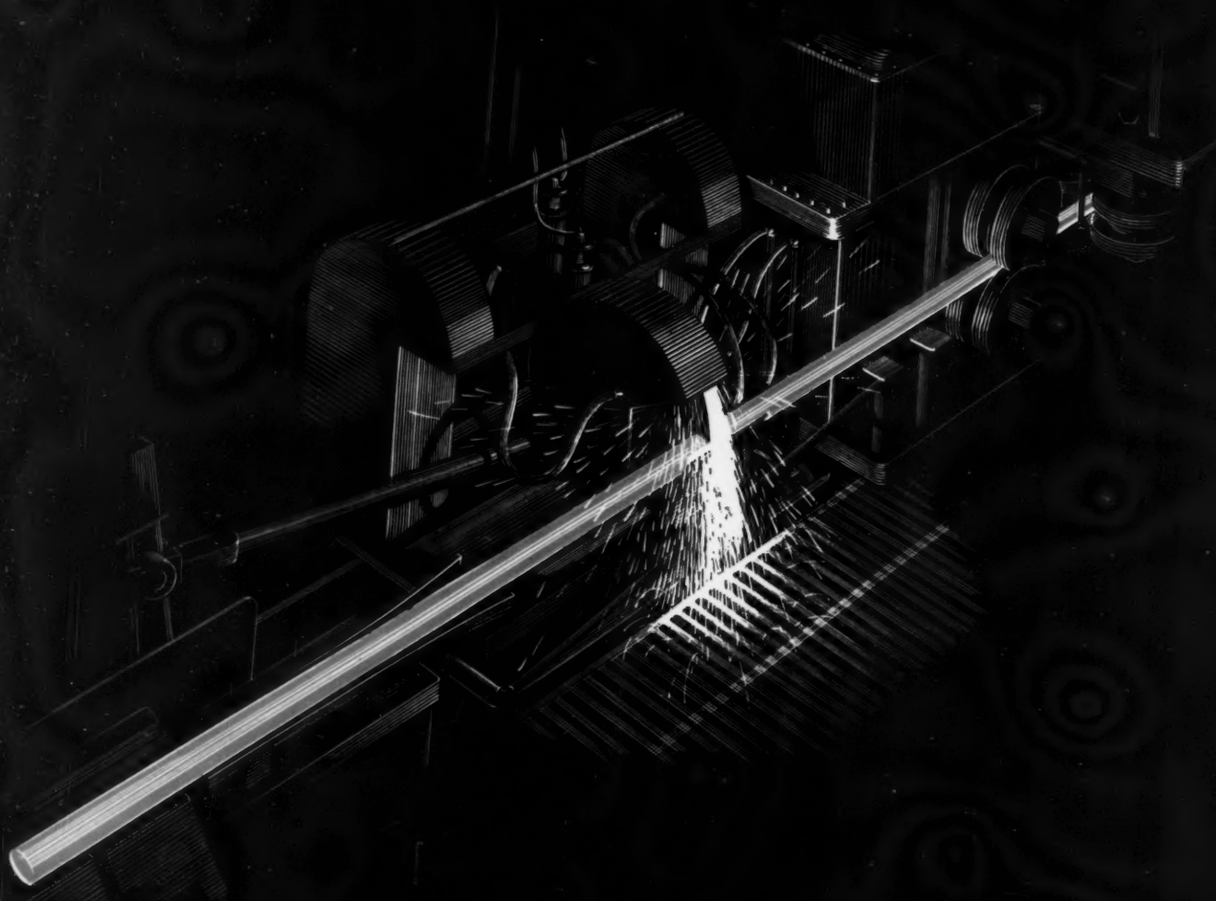
ELECTRICAL CONTROL APPARATUS

**NOTE:** Careful attention and inspection should be given to all electrical equipment, especially under war conditions where strain is severe and uninterrupted operation a vital necessity.

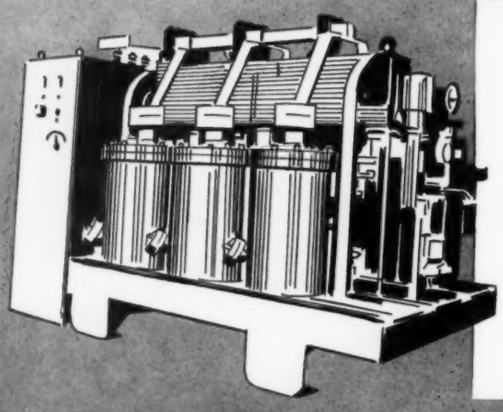
THE TRUMBULL ELECTRIC MANUFACTURING COMPANY • PLAINVILLE, CONN. • A GENERAL ELECTRIC ORGANIZATION

OTHER FACTORIES AT NORWOOD (CINN.) O. — SEATTLE — SAN FRANCISCO — LOS ANGELES

# Sawing hot pipe...



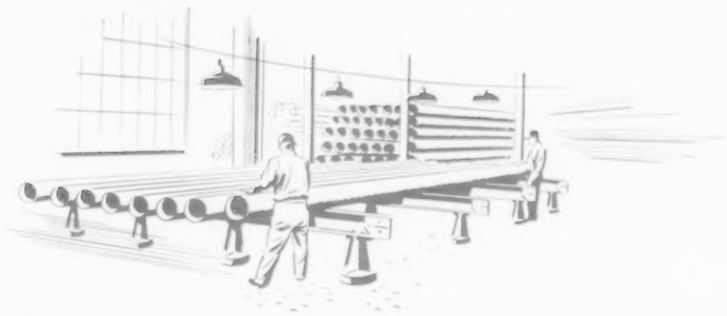
NEWS OF WESTINGHOUSE SERVICES AND PRODUCTS FOR THE STEEL INDUSTRY



## NEW FLEXIBILITY IN POWER SUPPLY

When Ignitron Rectifiers are adopted for power conversion, the power supply takes on new flexibility and adaptability. They handle high load swings with extremely high overloads—operate automatically and with a minimum of maintenance. Installation is simple—no special foundations required. For further information write for B-3129.

# AT DELIVERY SPEEDS UP TO 500 FPM



A steel manufacturer recently came to Westinghouse with a knotty problem. Production on his Fretz Moon pipe mills was limited by the speed at which hot pipe could be sawed into accurately measured lengths as it came from the mills.

The type of saw being used started and stopped for each cut. It could not be synchronized with the travel of the pipe. As a result, cuts could not be made to accurate lengths. Maintenance was high, and interruptions in mill operations were excessive.

Westinghouse engineers joined with steel company engineers in a search for the solution. The result was a "Flying Saw", which travels at the same speed as the pipe—cutting it into accurately measured lengths "on the run". It's all done with an ease and smoothness that eliminates maintenance and resulting interruptions in mill operations.

In effect, the saw carriage runs back and forth continuously along the moving pipe. For a brief instant in each round trip it is moving in the same direction as the pipe and at the same speed. In this instant the carriage tilts forward and the high-speed rotary saw slices through the metal. This complex job of timing and co-ordination is handled automatically, by electrical regulation and associated Westinghouse Synchro-tie.

Speed of the mills has been increased—to 500 fpm for half inch pipe, to 300 fpm for one and a half inch pipe. Thus, a production bottleneck has been removed, permitting the mills to turn out greatly increased tonnage of a superior product.

The "Flying Saw" is a good example of the kind of results obtained when customer engineers and Westinghouse engineers *team up* on steel industry problems. Westinghouse engineers are available to work with you on any problem involving electrical power. Just phone the nearest Westinghouse office. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. J-94543

**Westinghouse**

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

## WESTINGHOUSE ENGINEERING SERVICE

A nationwide corps of engineers offers you electrical and production experience gained through years of working with the steel industry.

In addition to engineering help on specific industry problems involving electrical power, these men can give you assistance on these other vitally important activities:

PRODUCT DEVELOPMENT: engineering of equipment to meet war requirements.

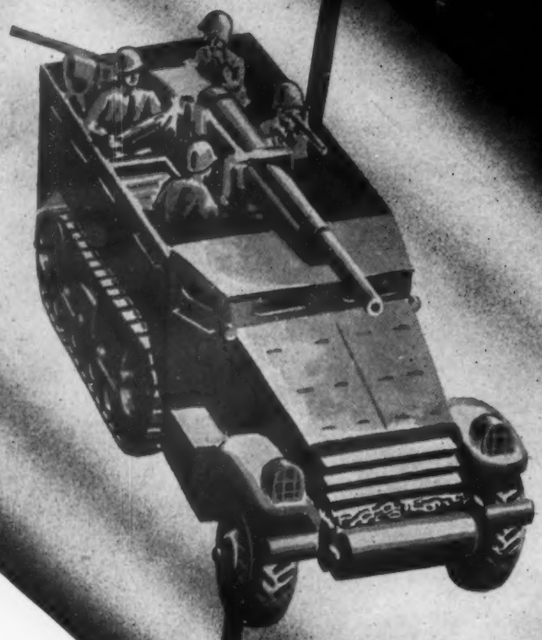
MAINTENANCE: help in making existing equipment serve better, last longer.

REHABILITATION: redesigning and rebuilding obsolete equipment for useful service.

MATERIAL SUBSTITUTION: adapting available replacements for critical materials.

W.E.S. is available to every branch of the steel industry. Put it to use today on your production problems.

# BETTER FINISH INCREASED TONNAGE



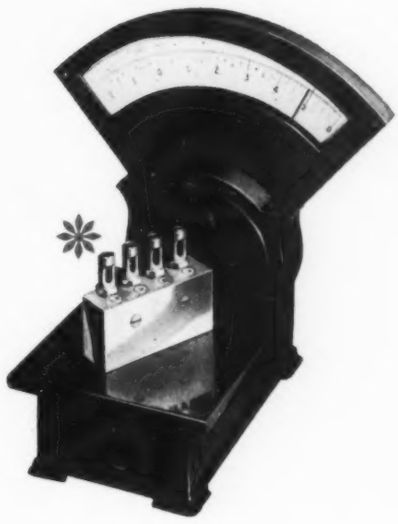
Let Lewis Rolls help answer the call for more and more production. Lewis research and experience in roll fabrication have contributed to the establishment of many production records.

**LEWIS FOUNDRY & MACHINE**
DIVISION OF BLAW-KNOX CO.
PITTSBURGH, PA.

# LEWIS ROLLS

Also manufacturers of **ROLLING MILL MACHINERY** for the iron, steel and non-ferrous industries

★ ★ ★ ★ FOR VICTORY BUY U. S. WAR BONDS AND STAMPS ★ ★ ★ ★



# *So little can save so much!

One 5-pound Farval Dualine Valve * saved over *2 tons* of critical bearing materials.

Total savings on this job through positive lubrication by Farval amounted to *over 200 tons of bearing metal* in less than one year.

And—75 Farval Valves on this Mill increased production by *375 tons* every 24 hours. This remarkable increase in output was obtained by eliminating the down time formerly required to lubricate, plus frequent shutdowns for bearing changes.

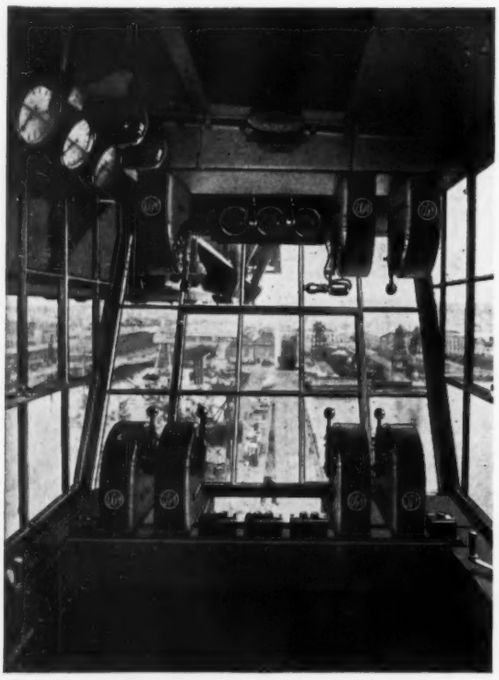
The Farval Centralized System of Lubrication will protect *your* production schedules too—and will save Time—save Men—save Power—save Bearings.

*So little saves so much!*

**THE FARVAL CORPORATION • 3278 East 80th Street, Cleveland, Ohio**
*Affiliate of The Cleveland Worm & Gear Company, Automotive and Industrial Worm Gearing*
*In Canada:* PEACOCK BROTHERS LIMITED

FARVAL
CENTRALIZED SYSTEMS OF LUBRICATION

# OF EC&M MASTER SWITCH MINIMIZES FATIGUE *aids* PRODUCTION



OPERATORS like the *exceptionally smooth* operation of this EC&M Master Switch (Type NT). It lessens fatigue—an even greater consideration today than ever before, with more and more women entering industry.

Furthermore, this switch, in combination with magnetic contactor control, produces a *quick response* in motor-driven machines. It gives *more accurate control* of machines and helps a lot in those inching operations.

An important feature, too, is its narrow width allowing several of these EC&M Master Switches to be lined up side by side—*and all easy to reach!*

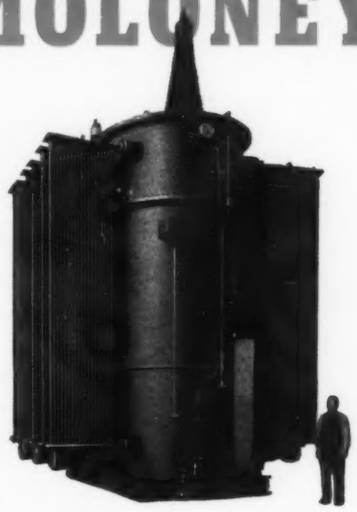
Bulletin 1182-1 completely describes this Master Switch for use with EC&M Bulletin 921 Crane Control or Bulletin 925 Mill Auxiliary Control. Write for your copies to-day.

E&M

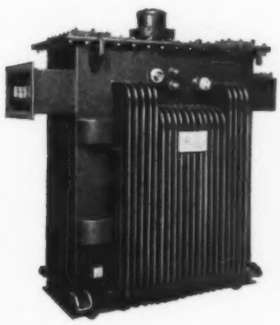
**THE ELECTRIC CONTROLLER & MFG. CO.**

CLEVELAND ★ OHIO

# MOLONEY TRANSFORMERS



Moloney Power Transformer. Transformer pictured above is rated 25,000 Kva, 161,000Y to 13,200 volts. These transformers can be supplied in any capacity or voltage desired.



Moloney Askarel (non-inflammable liquid cooled) Transformer. For indoor installation at load centers without the use of fire-proof vaults. Available in all Kva and voltage ratings.

Moloney Air-Cooled Transformer with Class B insulation. For indoor installation at load centers without the use of fire-proof vaults. Available in voltages up to 13,800 volts and in capacities of 150 Kva and larger.

## One of these MOLONEY transformers will meet your requirements . . .

Moloney manufactures transformers for all types of installations. If transformers of standard design do not fill your needs, our experienced engineering staff can design transformers which will exactly fit your requirements.

Disconnect switches, oil-fused cutouts, terminal boxes with potheads, forced-air-cooling, secondary air circuit breakers and many other features can be supplied on Moloney transformers.

Quick shipment can be effected whether the transformers are of standard or special design. Your inquiries will be given prompt attention.

**MOLONEY ELECTRIC COMPANY**
ST. LOUIS, U. S. A.

Moloney Conventional Distribution Transformer, oil-cooled, for outdoor pole or platform mounting. Sizes 1½ Kva to 500 Kva. Voltages up to 66,000 volts. Illustration typical of sizes 75 and 100 Kva, 7200 to 120/240 volts.

Moloney Completely Self-Protected Transformer, oil-cooled, equipped with built-in lightning and secondary overload protection. Sizes 1½ to 50 Kva. Voltages 2400 to 13,800 volts. Illustration typical of sizes 1½ to 25 Kva, 7200 to 120/240 volts.

Moloney General Purpose Air-Cooled Transformers with Class A insulation. For industrial use to serve lighting and small power loads. Left illustration typical of sizes 15 to 50 Kva. Right illustration typical of sizes 1 Kva to 10 Kva. Voltages 600, 480 or 240 to 120/240 volts.

### Moloney Transformers for every purpose

- Power Transformers
- Unit Substations
- Conventional Distribution Transformers
- Completely Self-Protected (CSP) Transformers
- Load Center Transformers
- Askarel (non-inflammable liquid) Cooled Transformers
- Air-cooled (Class A and Class B insulated) Transformers
- Constant Current Street Lighting Transformers
- Vault Type Transformers
- Submersible Type Transformers
- Furnace Transformers
- Shipboard Transformers
- Industrial Transformers
- Network Transformers

# 20,000,000 hp

OVER 20,000,000 horse-power bearing the Crocker-Wheeler name is serving the war effort, on land and sea.

Many of these motors and generators were built a generation ago . . . some were made in 1943. But all of them were built to stand up under unusual conditions.

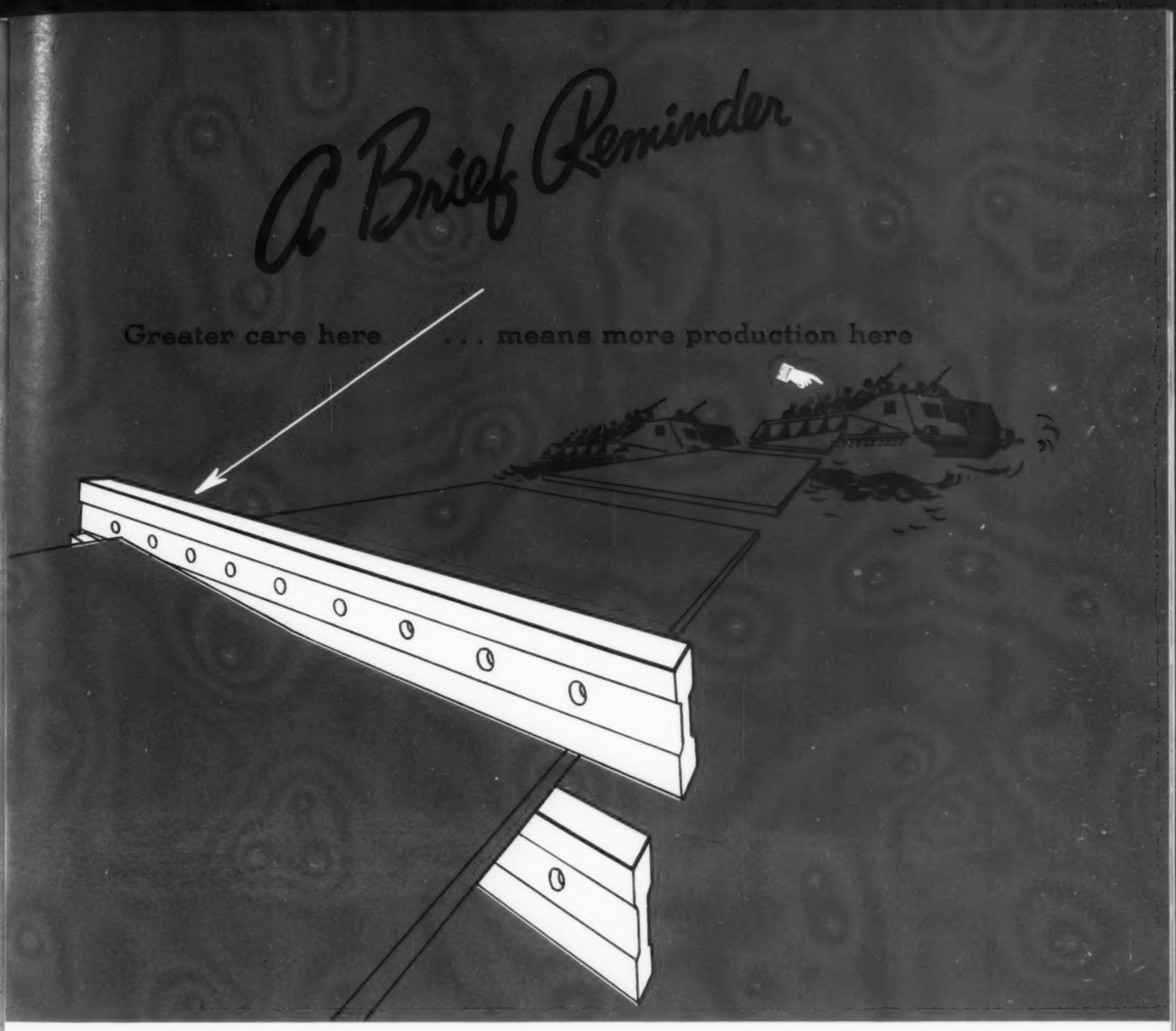
Watching over them is a corps of carefully trained field engineers, to whom the difficult and the unusual are all in a day's work.

We can make immediate deliveries on some types . . . consult your nearest Crocker-Wheeler office, or wire us.

Crocker-Wheeler Electric Manufacturing Co., Ampere, N. J.
Division of JOSHUA HENDY IRON WORKS

Be SURE . . . with
CROCKER-WHEELER

Other JOSHUA **HENDY** IRON WORKS factories at Sunnydale, Pomona and Torrance, Calif. and St. Louis, Mo.




*Reading Time: 25 seconds*

When you order shear knives, it's good insurance against waste of time and materials to specify the shearing job for which they are intended. Knives should not be used to cut a thickness or hardness of steel for which they were not designed. Then when the knives are placed in the shear they will perform better and last longer if studious care is exercised to maintain accurate clearance between the blades for the thickness of steel to be cut.

*20 seconds more*

Because Heppenstall makes its own E.I.S. steel and has the largest facilities for producing solid tool steel shear knives, it can offer faster delivery at lower priority ratings. Add that to well-known diamond-H quality, and you have good reasons for specifying Heppenstall when your knives need replacement.

To help speed your war work, Heppenstall offers you this free steel-weight calculator. Write now—the supply is limited.

**Heppenstall**

PITTSBURGH • DETROIT • BRIDGEPORT
EDDYSTONE

*Forging Fine Steels for Fifty-Three Years*

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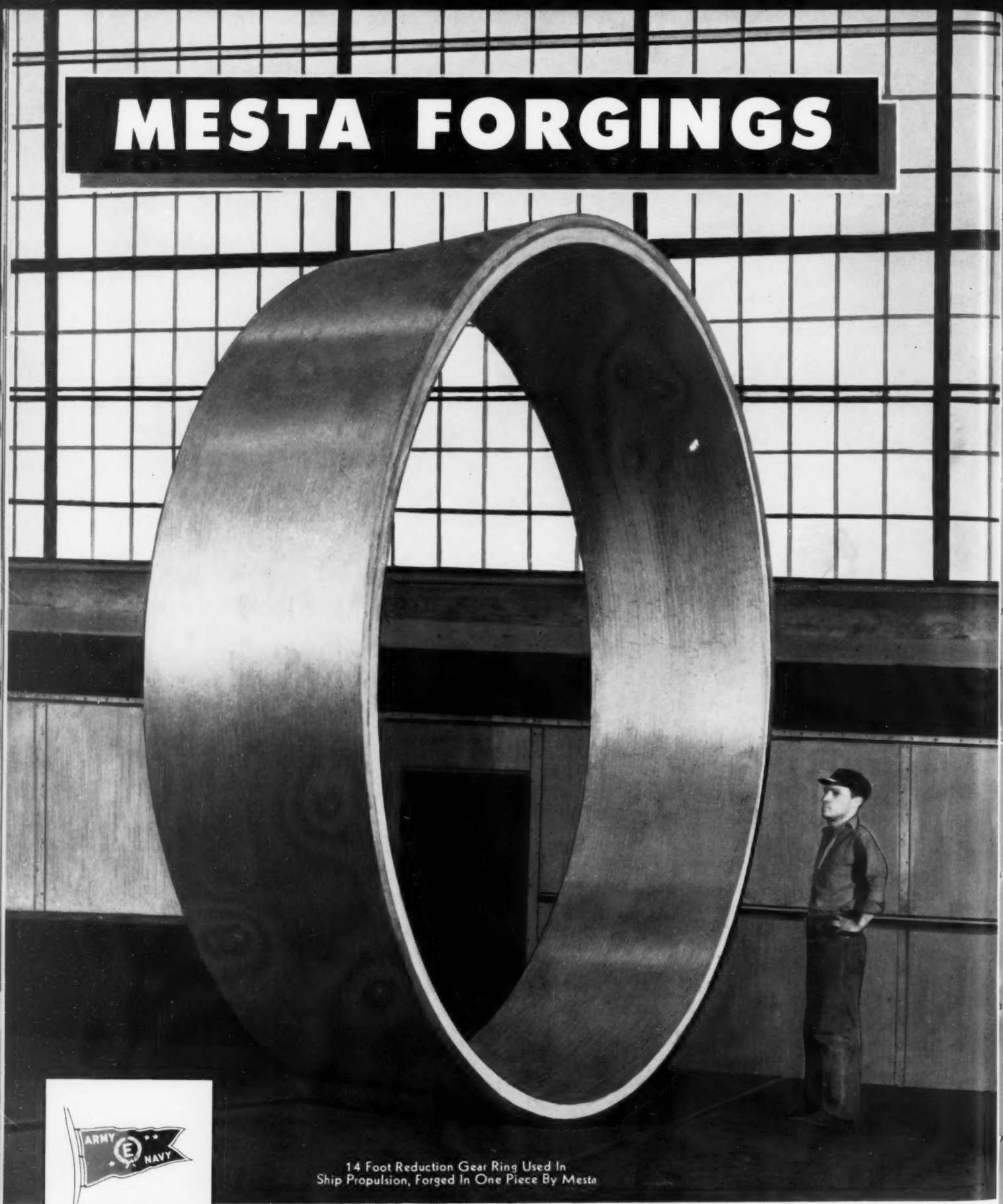
# MESTA FORGINGS



14 Foot Reduction Gear Ring Used In
Ship Propulsion, Forged In One Piece By Mesta




The Army-Navy "E" Flag
with three stars, flies
over the Mesta plant.

*INVEST TODAY IN BONDS FOR VICTORY*

**MESTA MACHINE COMPANY . . . . PITTSBURGH, PA.**

★ Just a little more than one year ago we were awarded the Navy "E" Burgee as a result of the tireless effort of "AUTOMATIC" employees in the continued production of equipment essential to the war effort.

Our organization, loyal to the core, has kept up the pace set when Uncle Sam first called for all out production.

So now, for the third time "AUTOMATIC" employees have won the Navy Production Award for meritorious service on the industrial field of battle.

**The SECOND SILVER STAR has been placed on the Navy "E" Burgee we so proudly fly.**

We'll keep it up—that is the spirit that prevails at "AUTOMATIC." Here we are all dedicated to the task of producing more and producing on time.

MANUFACTURERS FOR OVER 35 YEARS *Electric Propelled* INDUSTRIAL TRUCKS

**AUTOMATIC TRANSPORTATION CO.**

47 WEST 87th STREET DIV. OF THE YALE & TOWNE MFG. CO. CHICAGO, ILLINOIS

# HOW TO SPEED UP *Billet Chipping*

## Save TIME

A BILLETEER AND ONE OPERATOR WILL THOROUGHLY CLEAN ***10*** TO ***20*** BILLETS--WHILE AN EXPERIENCED HAND CHIPPER IS CLEANING ONE BILLET.

## Save MEN

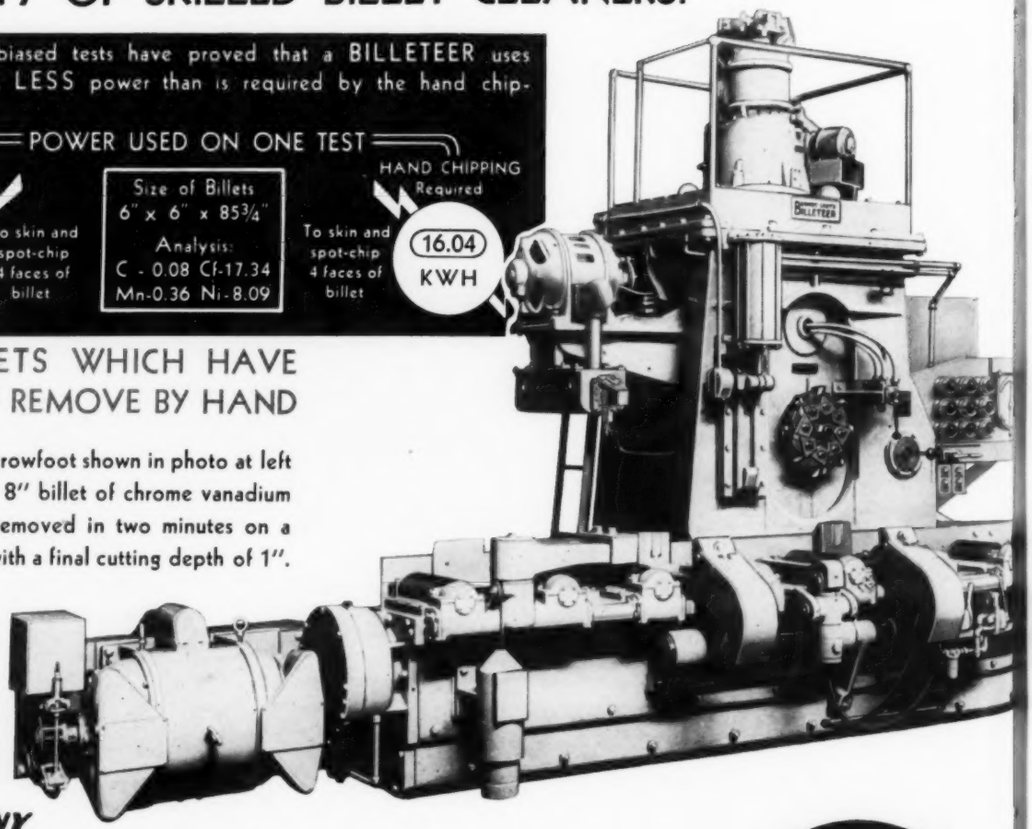
CHIPPING DEPARTMENTS COMPLETELY EQUIPPED WITH BILLETEERS ENABLE THE SHIFTING OF MOST OF THE MEN ON BILLET CLEANING CREWS TO OTHER IMPORTANT JOBS, OR PROVIDE THE ANSWER TO THE SCARCITY OF SKILLED BILLET CLEANERS.

## Save POWER

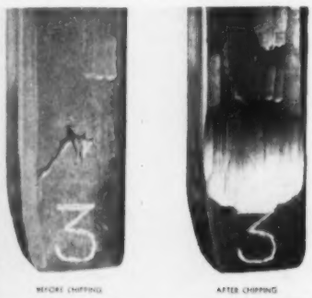
Rigid and unbiased tests have proved that a **BILLETEER** uses at least 60% LESS power than is required by the hand chipping method.

POWER USED ON ONE TEST

| BILLETEER Required | Size of Billets | HAND CHIPPING Required |
|---|---|---|
| 6.24 KWH — To skin and spot-chip 4 faces of billet | 6" x 6" x 85¾" Analysis: C - 0.08 Cr-17.34 Mn-0.36 Ni-8.09 | 16.04 KWH — To skin and spot-chip 4 faces of billet |



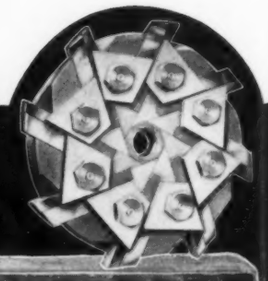
A BILLETEER SALVAGES BILLETS WHICH HAVE DEEP DEFECTS UNPROFITABLE TO REMOVE BY HAND



The deep crowfoot shown in photo at left on an 8"x 8" billet of chrome vanadium steel was removed in two minutes on a Billeteer, with a final cutting depth of 1".

WRITE FOR COMPLETE DATA

THE **Bonnot** COMPANY
STEEL EQUIPMENT DIVISION
CANTON, OHIO



TIMKEN BEARING EQUIPPED

BONNOT-LENTZ

# BILLETEER

A MECHANIZED SUPER PRODUCTION BILLET CHIPPER

*Pioneer railroaders had to literally cut their way through mountains.*

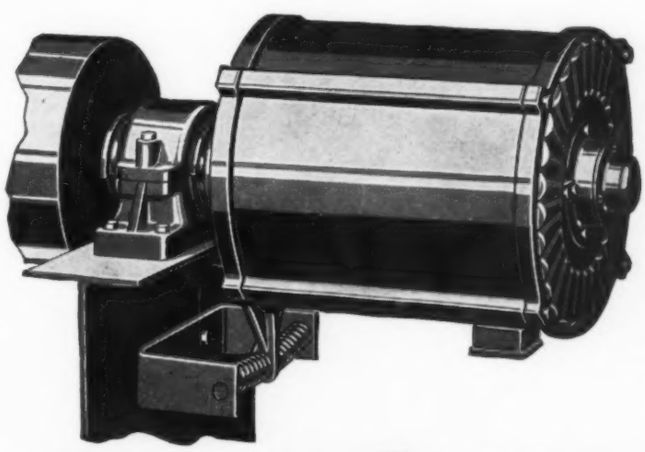
# CUTTING THROUGH

Reliance engineers have a well-established reputation for cutting right through habit and tradition in approaching difficult motor-drive problems.

For example . . . steel men frequently faced costly shutdowns for repairs and replacements caused by driving-motor and roller shafts getting out of line.

Cooperating with mill and roller engineers, Reliance got the answer by completely redesigning motors and mounting them directly on the end of the roller shaft, without coupling or gears.

If you design or use motor-driven machines, you can get a lot of practical ideas, based on wide experience in many industries by calling in a Reliance man.



*Reliance Floating-motor Drive. Motor, rigidly mounted on driven shaft, is anchored to table bed through two coiled springs that cushion starting, reversing. Floating-motor Drive simplifies and reduces cost of table construction; reduces installation and maintenance costs; roller and motor can be installed or removed as a unit.*

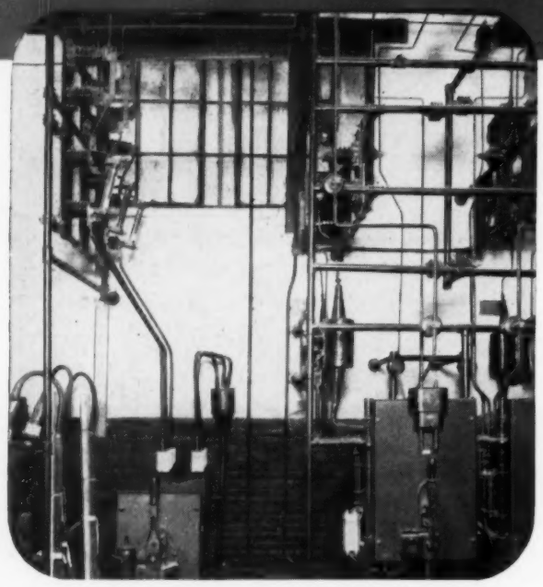
**RELIANCE A-C D-C MOTORS**

**RELIANCE ELECTRIC & ENGINEERING CO.**

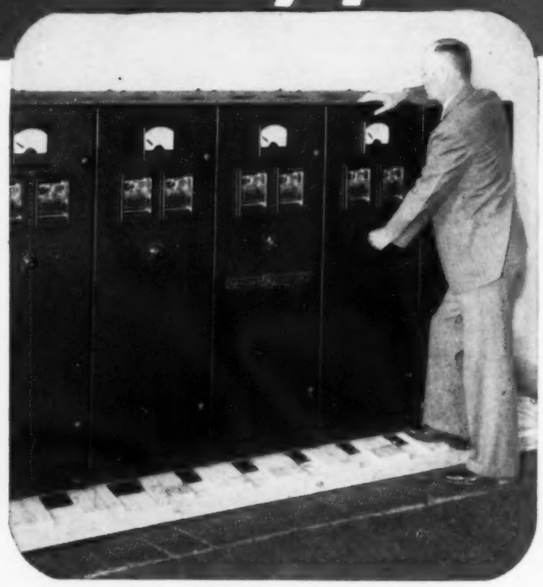
**1088 Ivanhoe Road · Cleveland, Ohio**

Birmingham • Boston • Buffalo • Chicago • Cincinnati • Detroit • Greenville (S.C.) • Los Angeles • New York Philadelphia • Pittsburgh • Portland (Ore.) • St. Louis • San Francisco (Calif.) • Syracuse (N.Y.) and other principal cities.

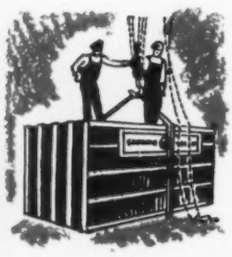
# METAL-CLAD *Reduces the Copper*



The ordinary, open-type switchgear construction takes approximately three times as much copper as a compact, safety-enclosed, metal-clad switchgear unit of similar rating. The installation shown above would take several times more copper.



Each circuit is fully enclosed in a separate, grounded-steel compartment so that closer spacing of circuits and smaller over-all size are obtained with far greater safety.



**COMPLETE CO-ORDINATION.** Each metal-clad, factory-assembled switchgear equipment is complete. It comes to you ready to install as a complete unit—for control and protection of your circuits up to 15 kv. All the devices and component parts are selected and built to work together. You get better protection for your power distribution system, to safeguard production. Also, your installation time and over-all cost are predictable and exceedingly low.

**SAFETY.** Live parts are completely covered—guarded behind walls of steel—and are designed to withstand short-circuit stresses equal to the rating of the breaker. Mechanical interlocks prevent careless opening. These factors combine to give you a higher degree of safety without the time, space, and cost involved in the construction of masonry-walled vaults.

**EASY MAINTENANCE.** Vertical-lift breakers are easily removable and can be inspected away from live parts. Breakers of the same type and rating are interchangeable and you can replace any one of them with a spare breaker in a few minutes. Swinging instrument panels provide easy access to small wiring for inspection.

# CONSTRUCTION *Needed in Switchgear*

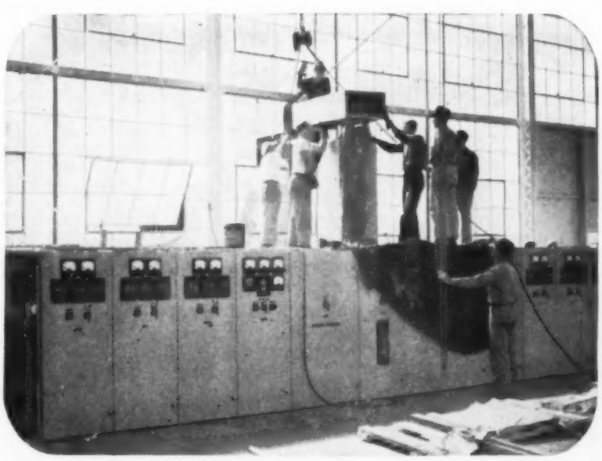
*THANKS TO STEEL,* G-E engineers have been able to make drastic reductions in the number and lengths of critical copper parts required in switchgear, at the same time producing safer, more compact, integrated equipment. By enclosing switchgear in walls of steel, they cut the need for vital copper so much that three compact, safety-enclosed units can be built now with the same amount of copper that it once took to build *one* of the old, hazardous, open type.

*THANKS TO STEEL* and standards, repetitive manufacture is easy and fast. If we had to use old-fashioned materials and methods today, even building to standard designs, we would need 20 to 35 times as many workers, machines, and floor space to keep up our present rate of production. These savings have been passed on to the purchaser in the form of reduced prices—a reduction of up to 35 per cent since 1938.

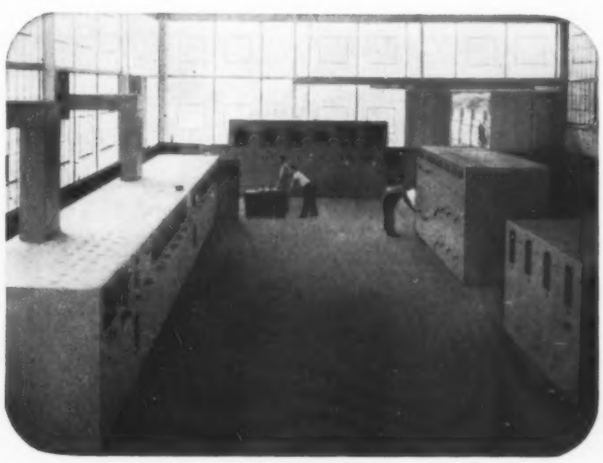
*THANKS TO STEEL,* modern, safety-enclosed switchgear needs no expensive, thick-walled masonry vaults. This wise economy of space means lower installation cost. Factory-assembled switchgear provides better control to ensure continuous production; better protection for the safety of all your personnel. Electrical hazard is eliminated by grounded steel.

★

*Ask your G-E representative for a copy of our booklet, "How to Conserve Copper in War-plant Electric Systems" GES-3031. General Electric Company, Schenectady, N. Y.*



Installation is quick and easy. Simply place the equipments where you want them, bolt them together, connect the power feeders, and they're ready to go to work.



Compact switchgear that incorporates its own control and metering equipment requires less space and reduces system cost, and maintenance is greatly simplified.

GENERAL ELECTRIC

854-24-7300

# STEEL MILL OPERATING CONTINUITY IS UNBROKEN *with*

# OKOLITE-OKOPRENE

The type of electrical cable used is an important item in assuring continuity of steel mill operation. The functioning of electrical equipment depends upon the reliability of the cable or wire through which the electrical energy is transmitted.

**FOR EXAMPLE,**

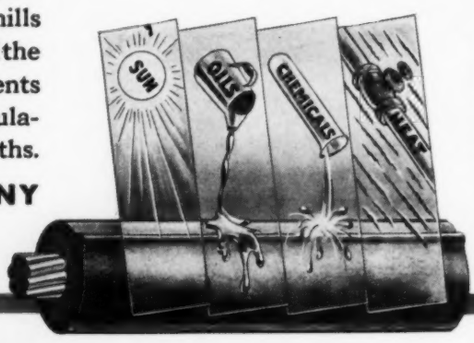
many mills are experiencing difficulty with cables because of solvent action, electrolysis, and corrosion, caused by ● cutting oils around pipe-threading machines, ● palm oil around cold strip mills and ● acid conditions around the pickling tanks. These elements attack and destroy cable insulation, braids and lead sheaths.

**THE OKONITE COMPANY**
**Passaic, New Jersey**
***Offices in Principal Cities***

OKOLITE-OKOPRENE cables are insulated with Okolite and protected with an Okoprene sheath. They have high current-carrying capacity and break-down voltage, low specific inductive capacity and power-factor. No lead sheath is required, thus eliminating electrolysis, and simplifying splicing and terminating. The Okolite insulation is an oil-base rubber compound which resists moisture, heat and ozone. The protective Okoprene sheath resists moisture, ozone, sunlight, oil, chemicals and flame and provides an air-tight covering of uniform thickness.

There are no braids to rot. The insulation and sheath are applied by the strip process and vulcanized in a continuous metal mold. Okoprene is produced in colors for circuit identification. The construction of Okolite-Okoprene is simple, flexible and long-lived.

Okolite-Okoprene is helping steel mills in their excellent conservation program.

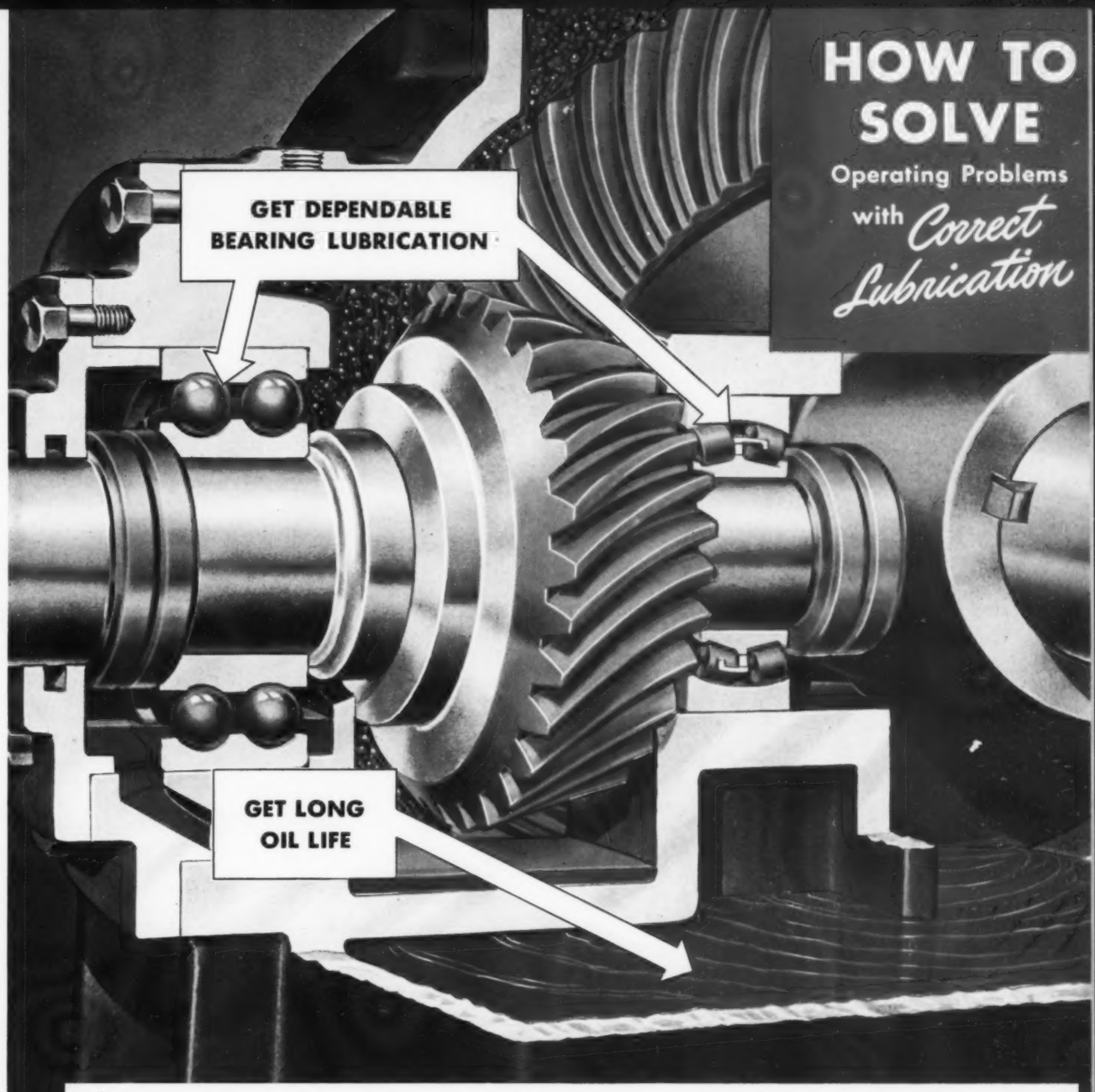



3220

**OKONITE** OKONITE **Insulated Wires & Cables**

***Salvage Your Scrap — Buy U. S. War Bonds***

ONE OF A SERIES OF SUGGESTIONS TO AID PRODUCTION




# HOW TO SOLVE

Operating Problems with *Correct Lubrication*

# Reduce Wear_Get a *Plus*, too

OF COURSE YOU WANT gear tooth wear kept to a minimum! Gargoyle Vacuoline Oil will help you do that in a splash or circulation oiling system. It forms an oil film of high lubricity and great strength.

But can you get more, too? What about the LIFE OF THE OIL? Does the oil you use separate easily from water? Is it free from emulsions and sludge? WHAT ABOUT THE BEARINGS? Does the oil you use protect them from damaging rust?

Here's the point: Gargoyle Vacuoline Oil does not only minimize wear. *It also minimizes rusting danger* in the bearings. *And it lasts long.*

Yes, by all means, *insist* on an oil that reduces tooth wear—but get the "plus" of long bearing life, long oil life by using Gargoyle Vacuoline Oil.

GARGOYLE
Lubricants

SOCONY-VACUUM OIL COMPANY, INC. — Standard Oil of N. Y. Div. • White Star Div. • Lubrite Div. • Chicago Div. White Eagle Div. • Wadhams Div. • Magnolia Petroleum Company • General Petroleum Corporation of California

## CALL IN SOCONY-VACUUM

*This*

# CONSERVATION PLAN

*will help you*

SAVE MAN-HOURS . . .

SAVE MATERIALS . . .

SPEED PRODUCTION

## 1. Conserve

by strategic selection, application and use of electrical equipment.

**EXAMPLE**

Standard gearmotors or speed reducers save materials required by sheaves, belts, chains and line shafts. In addition, they commonly effect power or energy savings up to 10.5%.

## 2. Conserve

by utilizing new developments that reduce need for critical materials and man-hours.

**EXAMPLE**

X-ray inspection detects defective castings or welded sub-assemblies before they are machined or assembled. It replaces "destructive" tests . . . reduces rejects . . . eliminates wasted machinery man-hours.

## 3. Conserve

by utilizing available facilities for preventing breakdowns and reducing machine outages.

**EXAMPLE**

"Maintenance Hints"—a complete, pocket-size manual covering recommended upkeep practice for electrical apparatus—is a maintenance help available without charge. Check your Westinghouse representative for copies.

## 4. Conserve

by utilizing materials which in many cases can replace critical materials and do a better job.

**EXAMPLE**

Micarta, a heavy-duty industrial plastic, outwears other materials in many bearing applications. Typical of many uses are steel mill roll neck bearings and marine stern tube and pintle bushings.

## 5. Conserve

by tapping all sources of salvageable scrap.

**EXAMPLE**

Systematic planning can uncover many ways of reclaiming worn equipment and waste material. Samples of salvage forms and organization charts in use in Westinghouse plants will gladly be made available on request.

Wartime Conservation means MORE than just conserving copper, steel, aluminum . . . it means the most strategic possible use of all of the ingredients of Victory—materials, man power, time and ingenuity.

These five major points comprise a complete program developed by Westinghouse for Wartime Conservation. This program packages up Westinghouse engineering experience in the entire field of electric and power equipment and related materials. Examples noted are but five of many specific recommendations.

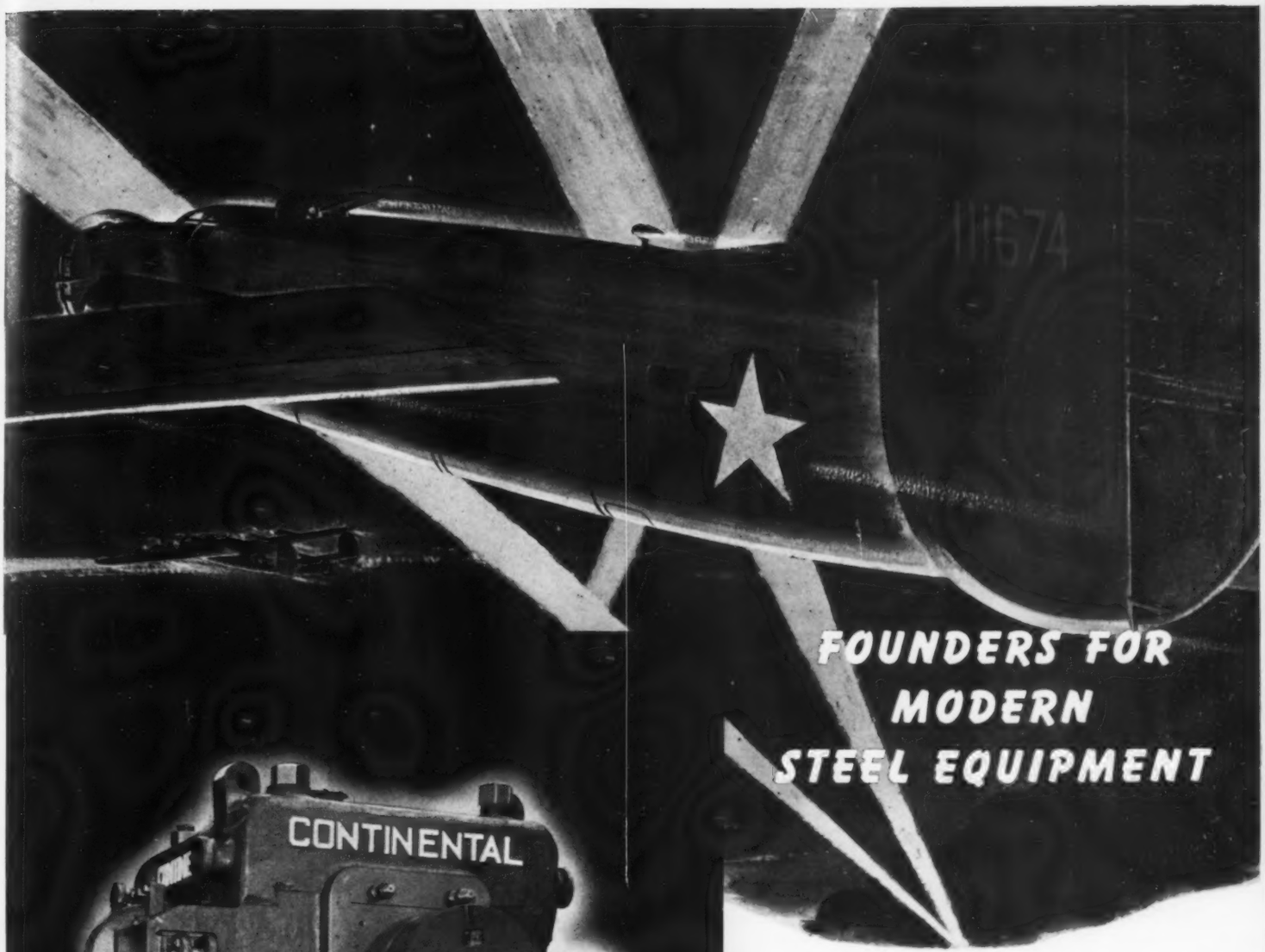
This experience and these recommendations are offered fully and without obligation.

Ask your Westinghouse representative today for a copy of the new 100-page book, "WARTIME CONSERVATION." Or write direct to Dept. 7-N, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

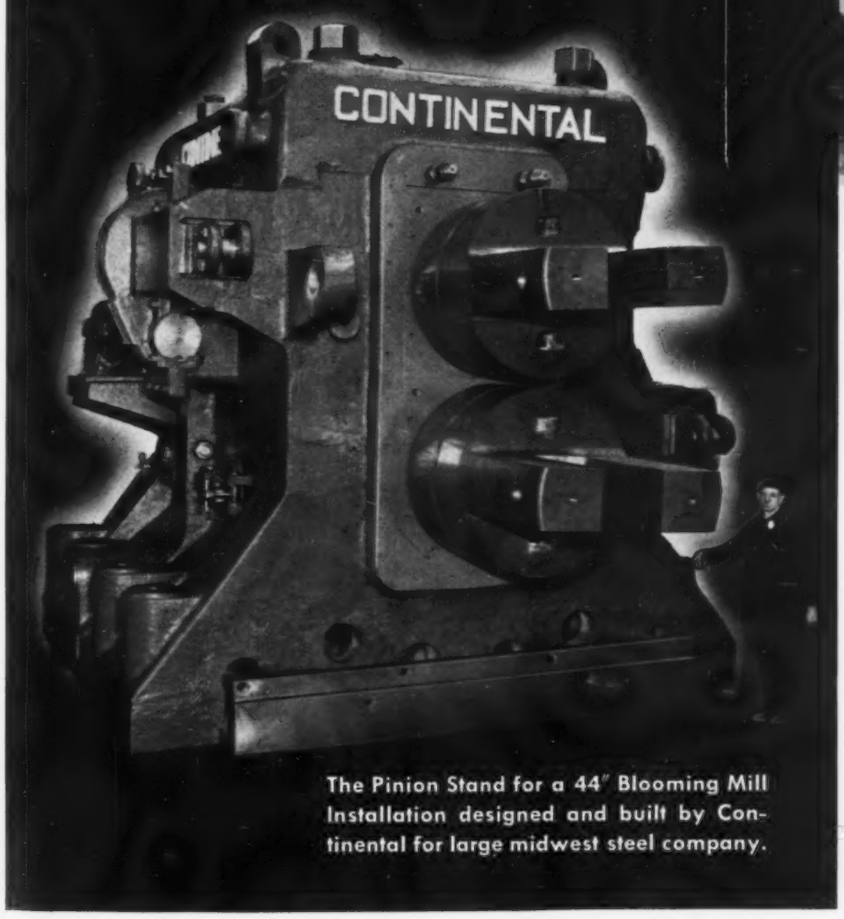
J-90481

Westinghouse

PLANTS IN 25 CITIES OFFICES EVERYWHERE



# FOUNDERS FOR MODERN STEEL EQUIPMENT




The Pinion Stand for a 44" Blooming Mill Installation designed and built by Continental for large midwest steel company.

ON BATTLE FRONTS all over the world the superiority of American production is destroying the might that once symbolized the power of the Axis.

Steel is doing a job, unequaled in the history of this industry. To make such production possible Continental continues to supply mills throughout America with precision products that meet today's requirements for highest speed production.

Consult Continental, one of America's largest producers of castings, rolls, rolling mill equipment and special machinery.

**CONTINENTAL ROLL & STEEL FOUNDRY COMPANY**
**CHICAGO • PITTSBURGH**

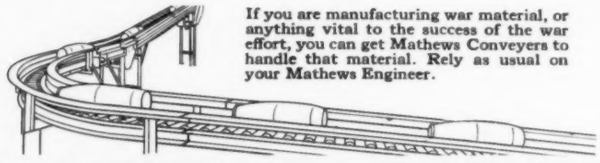
**STARS HAVE BEEN ADDED**
*to the Army-Navy "E" pennants now flying over Continental Roll and Steel Foundry Company plants in recognition for continued high production excellence.*

# *Continental Roll & Steel Foundry Company*

# THE *Strategy* OF MAN-POWER

**RELIEVING VITAL MAN-POWER** of unnecessary fatigue . . . avoiding unnecessary handling . . . saving unnecessary steps . . . keeping a constant flow of material moving to waiting hands and machines, that's man-power strategy headed towards victory.

America's war industries from coast to coast are improving their per-man-and-machine-hour production schedules with the aid of Mathews Time-Coordinated Conveyer Systems.



If you are manufacturing war material, or anything vital to the success of the war effort, you can get Mathews Conveyers to handle that material. Rely as usual on your Mathews Engineer.

MATHEWS CONVEYERS FOR MECHANIZED PRODUCTION

**MATHEWS CONVEYER COMPANY** ELLWOOD CITY PENNSYLVANIA

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**United States Army*

# IRON AND STEEL ENGINEER

JULY • 1943
VOL. XX NO. VII

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*Perfection in results*

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Lectromelt
FURNACES

**Pittsburgh Lectromelt Furnace Corporation**
**Pittsburgh, Penna.**

**The Furnace of Today and Tomorrow**

# Power INTERCONNECTION BETWEEN Steel Plants AND Utilities

***. . . . the exchange of power between utility and industrial plants, often used in the past to the economic advantage of both parties, is of particular interest in the face of present power conditions . . . .***

*by B. M. Jones and H. W. Dexter, Jr.*

**DUQUESNE LIGHT COMPANY**

PITTSBURGH, PENNSYLVANIA

▲ THE present emphasis on the conservation of resources — materials, machinery and manpower, has resulted in widespread consideration of the overall economies to be derived from interconnecting isolated electric generating plants of steel and other industrial firms with facilities of adjacent utilities. From the national as well as local standpoint, such tie-ins between all of the available electric generating sources in any area make possible the creation of a power pool from which all war and essential civilian industries and other needs may draw and which pool tends to bolster up the strength of each operating unit by reducing the necessity for the maintenance of large generating "reserves" in each of the several interconnected plants as would otherwise be prudent for continuous power supply.

It is on the basis of creating such power pools that the W. P. B. directed, in its power limitation order L-94, the investigation of such possibilities in every area of the United States. This directive assumed added importance in the light of the anticipated unusual load increases of those industries expanding for war work and the fact that it was necessary to withhold priorities for at least half of the projected plant expansions of utilities which would otherwise have been made to supply these war and other loads. Fortunately, practically all utilities and many industrial plants have been able to carry on despite these curtailments by drawing on their prudently provided reserves and by carefully planned usage of the overload ratings of the equipment installed.

Because no power shortage is anticipated here, the W. P. B. has not ordered the Duquesne Light Company to proceed with the installation of those interconnections in the Pittsburgh district which could be made with the minimum amounts of critical material. Yet the Duquesne Light Company, by investigating all instances of mills possessing electric generating capacity of 100 kw and above, has secured data from which these could be readily determined. In this territory, there appears to be about 40 plants which could contribute to a power pool, most of which plants already purchase some power from the utility for portions of their operations not supplied from their own generators. Of these 40 industrial stations capable of being pooled, 15 either operate on an interconnected basis or possess most of the necessary equipment to do this. It is the intent of this paper to describe and discuss certain of the features of seven of these fifteen interconnected industrial and steel mill generating plants, some of which have been in successful operation for more than 15 years.

Presented before A. I. S. E. Pittsburgh District Section Meeting, March 8, 1943.

## TYPES OF INTERCONNECTIONS

We ordinarily think of an interconnection between the isolated electric generators of an industrial plant with the lines of a utility as being an arrangement of facilities which permits the flow of power at any and all times either out of or into the plant's electrical system. If the mill's generators are a-c, this means that the two systems must maintain the same frequency regulation; that is, stay "in step." If the plant's generators are d-c on the other hand, some form of d-c to a-c conversion device must be interposed between the manufacturing concern's bus and the lines of the power company.

These "close" ties, particularly between the a-c systems, impose complications both in the selection of the tie equipment and the generators — if it is a new plant — to make such operation possible and controllable;

## TABLE I — Steam-Electric Generating Plant Data

| Case number | Electric generators | | | | Driving turbines | | | Steam for manufacturing | | Boiler plant | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number of units | Total capacity, kw | Machine output: Nominal voltage | Machine output: Freq. cycle | Throttle pressure, psi | Type of unit | Exhaust pressure, psi | Pressure, psi | How obtained | Header pressure, psi | Fuel | |
| 1 | 2 | 12,000 | 2,300 | 60 | 250 | Cond. | Vac. | 250 & below | Dir. & exh. | 250 | Coal & waste | Additional boiler cap. to be added. |
| 2 | 3 | 15,000 | 2,300 | 60 | 650 | Cond. & bleeder | Vac. & 150 | 150 | Exh. | 650 | Coal | Newest turbo-generators. |
| | 2 | 12,000 | 2,300 | 25 | 150 | Cond. & bleeder | Vac. & 2 | 2 | Exh. | 160 | Coal & waste | Units run condensing in summer. |
| 3 | 1 | 1,500 | 2,300 | 60 | 600 | Non-cond. | 150 | 150, 10 & 2 | Exh. | 600<br>150 | Coal & waste | Large process steam use at 150 lb. |
| 4 | 2 | 2,100 | 2,300 | 60 | 1–400<br>1–150 | Non-cond. | 150 & 2 | 150 & 2 | Exh. | 425 | Coal | Large process steam use at 150 lb. |
| 5 | 2 | 50,000 | 13,800 | 60 | 600 | Cond. | Vac. | | | 625 | Coal & waste | Units being installed. |
| | 2 | 17,000 | 6,600 | 25 | 250 | Cond. | Vac. | 250 & below | Dir. & exh. | 250 | Coal & waste | Additional gas-engine generators. |
| 6 | 5 | 60,500 | 6,600 | 25 | 2–450<br>3–250 | Cond. | Vac. | 250 & below | Dir. & exh. | 450<br>250<br>160 | Coal & waste | Additional boiler capacity to be added. |
| 7 | 1 | 35,000 | 13,800 | 60 | 700 | Non-cond. | 150 | 700 & below | Dir. & exh. | 700 | Coal | In process of construction. |

they also necessitate care on the part of the operators of the industrial's electrical system as well as those who supervise the functioning of the utility's adjacent lines, the central station's system operators. "Supervisory" or automatic control devices have been developed to reduce the work of the men who actually regulate the flow of kilowatts and reactive through such interconnections. The functioning and limitations of certain of these automatic regulating devices, those which are applied on the plants to be discussed, will be outlined later. The complexities of operating a-c systems in parallel are considerably more numberous than are those where an isolated d-c system is joined to an a-c utility — hence the cases to be considered are all instances of a-c to a-c ties.

As against such a parallel operation type of interconnection, suppose we consider the other kind of arrangement which does not involve the complexities of this type. Since the primary object of an interchange is to permit the transfer of power, another method of accomplishing this is by isolating generators or blocks of load in the steel plant and connecting these alone to the utility's lines. Very often these "loose" or "transfer" tie arrangements can be made without requiring all of the interconnecting equipment to permit the free flow of energy from the plant's generating system into the power company's lines, or vice-versa. This type of industrial-central station block transfer is illustrated by case 6, one of the cases to be considered; it is used by this plant, even though the major electrical apparatus is installed to permit limited parallel operation.

From the standpoint of the management of the manufacturing company, the ultimate decision as to the selection of a "close" or "loose" type of interconnection depends upon such economic considerations as first cost, dollar value of marginal power send-out or purchase, and other anticipated advantages of instant, maximum energy interchange. Under restricted conditions as exist today for the purchase of apparatus made up of critical materials, the type of equipment obtainable under the procurable priorities would probably determine the type to be adopted.

Even more important than this question of what type of interchange arrangement to select, are the considerations of "why interconnect at all?" Certainly, economic considerations are paramount in this, but the authors will confine themselves to a few of the major engineering reasons why interconnections were made in the cases to be considered.

### WHY INTERCONNECTIONS WERE MADE

Referring to Table I which outlines the steam-electric generating plant data and mechanical apparatus and other non-electrical features of the seven plants discussed, it is obvious that the data presented are extremely generalized. For obvious reasons, all plant names are omitted and many of the perhaps more interesting technical details are somewhat distorted. This table, however, is intended to present certain of the technical features which had a bearing on the initiation and operation of these interconnections.

The electrical connections and various associated matters will be described later on under that heading.

Case 1 is a plant which for many years was idle, and

which was purchased by an enterprising financial interest to be reopened and modernized. Careful studies showed that with new equipment the available waste fuels and heat would exceed its needs for the production of steam and electricity; from this it was evident that the excess might be used to deliver such power as would be available to the Duquesne Light Company if an arrangement could be effected to do this. A satisfactory basis was worked out for the interconnection — a 60 cycle, parallel operation one — the utility agreeing to reimburse the plant for its increment cost to produce the power and the industrial to purchase energy when, and if needed, at standard rates.

The generators, switching equipment and transformers for this tie were purchased by the industrial of the anticipated required capacity. A few years after the installation was in operation, unexpected troubles forced the shut-down of one of the plant's generators, and power was taken from the central station company instead of being delivered to it. Had a standby generator and appurtenances been purchased, they would have cost almost as much as the plant's interconnecting substation equipment.

Load growth within the plant has subsequently eaten up the excess steam availability so that now this plant is constantly drawing on the Duquesne Light Company for several thousand kilowatts. Along with this increase in process steam load, there has also occurred an increase in internal electrical load. Just recently, priority approval has been secured for more boilers, but even with these the installed generators will just about supply the firm's own electrical requirements. The interconnection will be retained in parallel to insure adequate power supply for manufacturing.

Another of the industrials, case 2, possessed an old 25 cycle generating plant from which it carried a portion of its manufacturing load, the newer portions of the plant being equipped with 60 cycle apparatus for which the energy was purchased from Duquesne Light. All of the steam necessary for its process and heating operations was delivered by the existing 160 lb boilers and equipment, but the load balance was shifting to the 60 cycle side. Under these and other conditions, the decision was reached to replace both the boilers and turbines in the generating plant and to have the newer units produce 60 instead of 25 cycle energy. This change was made in steps and the 60 cycle equipment was arranged so that it would operate in parallel with the utility's existing service; thereby, the new generators could deliver electricity into the interplant, 60 cycle system without disturbing the existing facilities.

In the plans for this plant, no spare 60 cycle generator was provided, but one of the older 25 cycle units was retained as a spare for this portion of the plant load. Only sufficient boiler capacity was provided to handle the major portion of the 25 and 60 cycle loads. Twice during the rebuilding program, difficulties in the 60 cycle generating station forced shut-downs and the extra load was carried by the power company.

As noted in Table I, the new boilers are 650 lb units, and steam for manufacturing and heating is obtained by bleeding certain of the turbines.

The third existing manufacturing company, case 3, was purchasing all of its electricity but used a large amount of steam at 150 and 10 lb for mechanical drives, heating and process work. Several years ago, the boiler plant of this firm required rebuilding; a higher pressure, 600 lb, was chosen for the new boilers and a back-pressure turbo-generator to deliver 150 lb steam was selected as a reducing valve. This generator is large enough to deliver only a portion of the plant's existing electrical requirements.

Another of the firms, case 4, which now operates 60 cycle generating equipment in parallel with the central station company's lines, was planning the erection of a large plant addition. This addition required a considerable amount of steam at 150 lb pressure; it would also involve more electrically operated machinery. Engineering surveys revealed that a part of the electrical load could be generated by passing the required steam through a turbine between an initial pressure of around 600 lb and the back pressure desired. The boilers and generator for this set-up were installed and the unit tied into the regular mill 60 cycle system which was extended to the new buildings. Increases in electric load in other parts of the plant have been taken care of by adding to the purchased power facilities from the Duquesne Light Company.

Some years ago, the managements of two of the larger industrials, cases 5 and 6, operating 25 cycle, a-c generating plants, totally isolated from the utility and each fully loaded, were desirous of expanding their manufacturing facilities. New manufacturing equipment of the type selected had been developed for use with 60 cycle motors but could be obtained for 25 cycle drive at greater cost. This same condition of development and cost differential between 60 and 25 cycle motored machinery held true with other more modern apparatus for their processes. In the light of this, they both decided to embark on future programs of 60 cycle operation where feasible, purchasing their new mills with 60 cycle drives and obtaining the energy for these from the Duquesne Light Company.

From these beginnings, they each have added additional 60 cycle manufacturing machinery, have replaced some 25 cycle machinery with 60 cycle, and have made limited replacements and extensions to their 25 cycle systems. One firm, case 6, has added to its 25 cycle generating facilities to supply its existing 25 cycle load while the other, No. 5, has selected 60 cycle units for its newer, 60 cycle load. Both have added conversion devices to permit interchange between their 60 and 25 cycle systems.

At present, the mill loads of both of these companies rises at times beyond the capacities of their own generating and steaming facilities, including all reserves, with the result that these two interconnections are really functioning as sources of supply from the utility. Even with the additional 60 cycle generators of plant No. 5, and the greater boiler capacity of case 6, the light company will still be called upon to supply portions of their wartime loads.

Plans for a new chemical plant, case 7, called for large amounts of steam with some at relatively high pressures. Rather than install pressure-reducing valves to deliver the portion of the steam at the lower pressures, it was decided to provide a turbo-generator of the back-pressure or bleeder type to use all of the steam required at the lower pressures and generate electrical energy with this unit. The capacity of this machine

exceeded the electrical load requirements of the plant; hence arrangements were made to deliver the excess by means of an interconnection to the Duquesne Light system.

A large portion of this plant will be ready for operation before the generating equipment will be ready; hence the utility's lines and facilities will be available to operate the completed parts of the plant even before the power station is completed. Suffice to say, no "spare" generator is being provided, since the back-up of the light company's lines will provide the reliability of power source required for the plant's continuous chemical production processes.

We would like to point out that these interconnections were not made due to power shortages on the Duquesne Light system, for no power shortage has existed in the past nor do we foresee any shortage for our system on the basis of the latest forecast. These forecasts are based upon the best available load data from all sources of which we have any knowledge, and include the loads that are expected on our system as a result of governmental assignments of war activities to our territory. We will have sufficient reserve, including the two 40,000 kw ties, to handle the expected loads under all normal conditions of operation during the present war emergency.

In the early part of the article, reference is made to W. P. B. power limitation order L-94, and, as was stated, it has not been put into effect in the Pittsburgh area, but a study had been requested. This study involves the determination of how much power can be obtained from interconnections with private plants and the amounts of critical materials required, all on two bases:

1. A feasible amount of power available, using minimum amount of critical materials.

2. The maximum amount of power that can be obtained, which, of course, will require more materials in most cases.

A preliminary survey of some of these possible interconnections discloses that, as a result of the interconnection with the Duquesne Light system, a considerable portion of the industrial plant's electric system will have to be rebuilt entirely and/or replaced with larger and adequate equipment. This applies particularly to the points of interconnection, and involves equipment, such as circuit breakers, fuses, etc., but will affect to a lesser degree other parts of the industrial plant's electric system. In some cases, a portion of the industrial plant's generating capacity can be isolated and paralleled with the Duquesne Light system with a minimum use of critical material, and in these cases the remainder of the industrial plant's system will not be affected.

## TECHNICAL DETAILS

The seven interconnections we are describing in this paper are shown on Figure 1, which is a schematic diagram of the Duquesne Light transmission system with the connections to these plants shown thereon.

Cases 1, 2, 3 and 4 are parallel operating plants, and cases 5 and 7 will be parallel operating plants in 1943. Case 6 is a "load shift interconnection" with no paralleling to make the shift, the load actually being dropped momentarily.

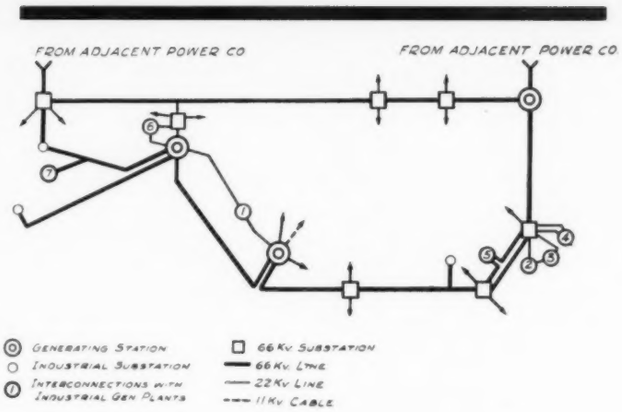



**Figure 1 — Schematic diagram of utility system showing seven interconnections with industrial plants.**

Duquesne Light supplies power under normal conditions to plants in cases 1, 2, 3 and 4, but, of course, may take power under abnormal conditions. During the 1936 flood when our transmission system was disrupted, we took power from any and every source available, including cases 2, 3 and 4.

Case 5 is the largest interconnection and will be in service in 1943. The present proposal is for the Duquesne Light to supply a considerable portion of the 60 cycle load, and the industrial plant's 60 cycle generators to supply the balance. The customer's frequency changer (60 cycle to 25 cycle) will also supply under certain conditions power from the common 60 cycle system (of the utility company and the industrial plant combined) to the customer's 25 cycle system.

Case 7 will be in service in 1943, and Duquesne Light will provide power for a considerable portion of this load (about 16,000 kw) prior to the generating plant being in service, and thereafter the Duquesne Light will take about 19,000 kw from this plant.

In addition to these a-c interconnections, there are several d-c interconnections which will be touched upon briefly at this point. In some instances, the industrial plant's d-c generating equipment operates in parallel with conversion equipment connected to the utility system lines. At other plants, one or the other usually carries the load, while at other times there may also be parallel operation. There can be no appreciable backfeed with these usual arrangements, for a rotary converter of the usual design for instance, connected to the utility system lines would not perform satisfactorily if operated inverted (d-c to a-c).

It is interesting to point out along the general subject of interconnections, that the Duquesne Light ties in with other utilities as shown in Figure 1, each of these being a 40,000 kw interconnection. The power pool on which these two interconnections can and do draw, has an installed generating capacity of four to five million kilowatts. This power pool has been in very satisfactory operation for a number of years and has been increased over that period of time, both in generating capacity, and in number and size of interconnections between power companies.

A recent example of the benefit derived from such an interconnected power pool was the occasion when a

large amount of generating capacity, several hundred thousand kilowatts, was taken off the line quickly by one of the other power companies and this load was picked up immediately on the large interconnected pool without any undue disturbance whatever. In fact, the customers probably did not know about it at all. Of course, this situation necessitated other generators in the pool picking up this load, and also caused considerable redistribution of load among the transmission lines and ties. There have been many other occasions where the pool has been very useful for emergencies.

Both of the two large interconnections of the Duquesne Light Company with the pool have been in service since about 1925.

Engineering investigations of many matters must be made to determine the most suitable and least costly method of making the interconnection. Some of the important features to consider are shown below, and some of these items are further discussed later on.

1. Size of interconnection — amount of power flow to be handled in each direction, initially and in future. Should be carefully studied as it is generally cheaper to provide for it initially.

2. Control of the flow and reactive — how, when, and by whom.

3. Emergency conditions — what to provide for — how many lines — floods, etc. The amount of reserve and degree of security desired will determine this point.

4. Interconnecting substation and supply lines — type, design, capacity, and location.

5. Short circuit duties — amount that will be imposed, and how to reduce them or alleviate their effect if excessive — initially and in future. This item will be discussed further in the discussion.

6. Relay protection — an important item, and a complicated one on a large interconnection; always requires sound engineering. Adequate protection should be provided for all conditions of both parties which affect the operation of the interconnection. This will be covered further later on in the discussion.

7. Frequency regulation — generally the utility holds very closely on this, and the industrial plant must operate to suit. This may be a difficult problem with old generators. Most industrial generating equipment operating isolated can control its load and voltage regulation, but when interconnected with a modern utility system it just cannot regulate the frequency.

8. Stability — may be particularly difficult at some installations. Assurance must be made that the industrial generators will stay on the line and ride through disturbances on both systems.

9. Effect of swinging or fluctuating loads — usually no problem, but may require extra facilities. If a large interconnection, no extra facilities required generally.

10. Voltage regulation — generally not a difficult item, but it must be sufficient. Important in connection with power factor control features.

11. Communication — must be available to proper persons in both organizations at all times. Particularly important on large interconnections. This is an important operating feature, and personnel acquaintanceship helps. Should be carefully worked out to cover all requirements.

12. Load dispatching — should be agreed upon in advance as to just how to operate to meet needs of both parties, and should be followed without too much interference. Some degree of flexibility should be available in the contract.

13. Supervisory control and remote load indications of the interconnection — must have sufficient control and load data to permit maximum beneficial operation of interconnection to both parties. Data on power flow over the interconnection should be available to the dispatching forces at all times in many cases.

14. Metering — this is a very important item and one that becomes more so for larger installations. Modern metering equipment is available to meet the needs. Both parties should see to it that adequate metering is installed.

15. Power factor — important, and more so on large interconnections. Requires careful study in advance and may require power factor control equipment.

16. Co-operation and exchange of necessary data — the engineers and operators should work it out and then get the executives to pass upon it. Remember that it must be a mutually satisfactory interconnection.

*Short circuit* — The short circuit duty for the plants considered is shown in Table II, and naturally the interconnection increases the short circuit duty in the industrial plant. Some real intelligent engineering has to be done to avoid excessive expenditure of money, due to the necessity of replacing breakers (or reducing the duty in some manner) as a result of the larger short circuit. Further, the replacement and rebuilding of bus structures and other electrical equipment which in many cases is unable to stand the short circuit may also require much money and material.

Sequential tripping, also referred to as cascaded relaying, will provide an inexpensive means of relieving the overdutied breakers in many cases, and is accomplished by holding in the small breaker and letting an adequate breaker interrupt the short. To do this, the relays of the smaller breaker are set slightly below its capacity, and when these relays operate they interrupt the tripping circuit of the smaller breaker and they also trip the large adequate breaker. The smaller breaker trips for shorts within its capacity. The Duquesne Light Company has been using this scheme with entire satisfaction for a number of years, and so have many other companies.

*Relaying* — In any large electrical installation, the relay protection is important, and the larger and more complicated the installation, the more important the relay protection becomes. This matter of providing adequate relay protection is very important on an interconnection between a large utility system and an industrial plant, particularly where the industrial plant itself has large generating capacity.

Care must be exercised to provide adequate relay protection for the various conditions that must be met, and the main protection items to be provided for are listed below, while Table III lists the actual relay protection provided for the seven large interconnections.

1. Reverse power protection for both the utility lines and industrial plant lines and equipment for grounds and short circuits.

2. Overload and differential protection for grounds and short circuits for busses, banks and generators. This is not particularly special for interconnections, although it must be coordinated with other protection.

## TABLE II — Supply Line Data and 60 Cycle Short Circuit Kva for Interconnections Between Duquesne Light System and Seven Large Industrial Plants

| Supply line data | | | | | Maximum breaker duty at various 60 cycle voltages Short circuit kva — instant. symmetrical values | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Case | Figure | Kv voltage | Number of lines | Size | Kv | Contribution from D. L. system | Contribution from industrial systems | Maximum breaker duty | Total bus S. C. |
| 1 | 2 | 23 | 2 | 4/0 | 23<br>2.3 | 259,000<br>103,000 | 45,200<br>191,000 | 304,200<br>294,000 | 349,400<br>294,000 |
| 2 | 3 | 23 | 3 | 4/0 | 23<br>2.3 | 334,000<br>49,600 | 77,400<br>114,200 | 411,400<br>163,800 | 411,400<br>212,400 |
| 3 | 2 | 23 | 2 | 4/0 | 23<br>2.3 | 257,000<br>91,000 | 19,500<br>23,500 | 276,500<br>114,500 | 453,500<br>114,500 |
| 4 | 2 | 23 | 2 | 1/0 | 23<br>2.3 | 163,000<br>31,200 | 18,100<br>34,100 | 181,100<br>65,300 | 181,100<br>65,300 |
| 5 | 4 | 68 | 2 | 4/0 | 68<br>13.8 | 735,000<br>None | 431,000<br>446,000 | 1,166,000<br>446,000 | 1,166,000<br>683,000 |
| 6 | 3 | 23 | 2 | 4/0 | 23<br>6.6 | 227,000<br>104,000 | 19,400<br>22,100 | 246,400<br>126,100 | 334,400<br>126,100 |
| 7 | 2 | 68 | 1 | 1/0 | 68<br>13.8 | 556,000<br>223,000 | None<br>391,000 | 556,000<br>614,000 | 747,000<br>614,000 |

NOTE: Short circuit contributions from some synchronous motors and motor-generator sets are not included so as to simplify calculations for this table, but their effect has of course been taken into consideration on each actual job.

3. On many utility transmission circuits, automatic reclosing is practiced and equipment must be provided to disconnect the industrial plant generator from the utility lines or system, so that when the utility line is re-energized for trial after fault, the industrial plant's generator will not be paralleled with the utility system when out of phase.

4. Protection to insure that the industrial plant generator will not keep the utility system transmission lines energized in event of faults on the utility circuits. This protection is over and above item 1 above and is, under certain conditions, a kind of back-up for item 1.

5. Facilities to prevent the industrial plant's generator from tripping his own or the utility circuits during faults on other parts of either system.

*Communication* — This is essential on the larger interconnections and is very desirable and helpful on the smaller ones. We do now have telephone communication to several industrial plants of appreciable size or in isolated locations whether there is an interconnection or not.

For case 5, there is a direct Duquesne Light telephone line between the load dispatchers of the two companies and between them and the interconnection substation. For case 7, the utility company proposes a direct telephone communication to the interconnection substation and to the generating switchboard room of the customer.

*Remote load indication* — This is a very desirable feature, and on large interconnections is practically essential. However, on smaller ones it is not so important as the Duquesne Light Company has in all cases telephone communication with the industrial plant. Obviously, this would be of minor interest for installations where the utility supplies by far the larger part of the industrial plant load and the customer's generator is relatively small, as for instance, case 3. However, in case 5 where there is 50,000 kva, 60 cycle generating capacity in parallel with the Duquesne Light Company, it is very desirable, even though there is no intention to take power into the utility system over this interconnection at the present time.

For case 7, remote indication is proposed, for after this generator is in service it will be supplying approximately 19,000 kw into the Duquesne Light system, and hence in effect will be just another generator so far as Duquesne Light's load dispatching is concerned.

All reference to load indication applies to the flow between the two systems, and insofar as load on the industrial plant's generators is concerned, it is only of academic interest to the utility.

*Metering and billing* — Adequate metering must be

provided in the interconnections to take care of the power flow in both directions, and to be able to measure quite a wide range of power and power factor. It will be found desirable to have a limit to the band of power factor that will be taken into either system, as this will affect the wattless flow and voltage regulation, and hence the overall general system performance of the receiving system. Modern metering equipment is available to accomplish this.

A word of caution here: Any contract to be made should cover this point very carefully so as not to run into operating limitations in the future.

*Grounding* — The electric system in each of these seven plants is not grounded at the incoming line voltage. Case 7 is the only one of the industrial 60 cycle electric systems grounded beyond the first transformation and it is grounded at 13.8 kv by means of a grounding transformer on the bus.

Duquesne Light's 66 kv and 22 kv transmission systems are grounded through 63 ohms and 3.75 ohms respectively at several places each. On both the 66 kv and 22 kv systems complete ground relay protection is provided.

### CASE 1

This is a very good example of an interconnection between a utility and an industrial plant, for power has been interchanged both ways over a number of years, involving a wide range of business conditions — all to the satisfaction of both parties. This interconnection has been in existence for 15 years.

Figure 2 shows the diagram of connections for this interconnecting substation, and the entire installation, including the substation, Duquesne Light lines, and industrial plant generators, was made initially. The short circuit values and breaker duties appear in Table II, and the equipment selected was suitable for the immediate duties, with some margin for future expansion.

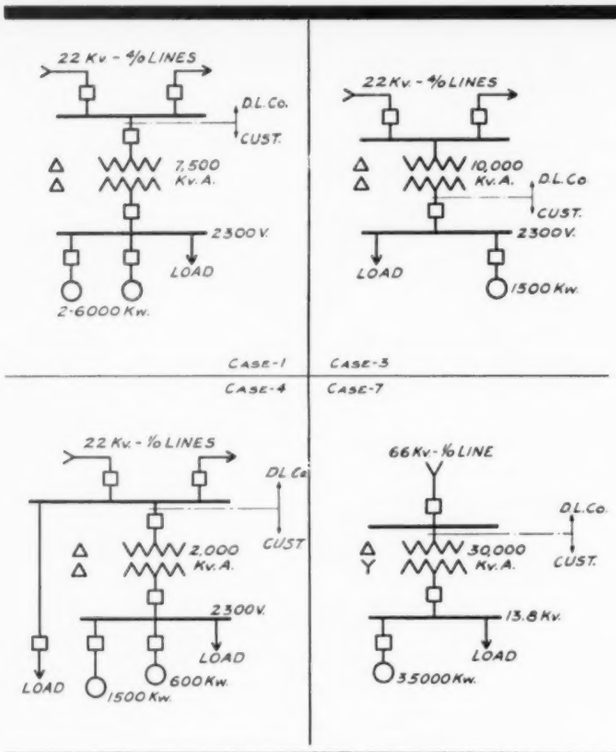
The relay protection consists of power directional relays on the two incoming utility lines, high tension bus protection, and other necessary relay items, all as shown for case 1 in Table III. Out-of-synchronism relay protection is provided and is similar to that described for case 3.

### CASE 2

This interconnection has been in use for more than 15 years, and for a number of years the utility company provided power for this industrial plant by means of paralleling through a 2500 kw, 60 cycle to 25 cycle, frequency changer set connected to the 22 kv line bus through two 5000 kva transformer banks. However, this frequency changer set is not now in service and actually is more or less a standby source for the 25 cycle generating equipment. Later, parallel operation

**TABLE III — Relay Protection Provided on Interconnections Between Duquesne Light System and Seven Large Industrial Plants**

| Case number | H. T. line protection | H. T. bus protection | Prevent reclosing of lines out of syn. with cust. generator by | Separates the systems by means of | Permanent ground fault on utility lines when supplied only by cust. gen. cleared by | Normal direction of power flow |
|---|---|---|---|---|---|---|
| 1. | Power directional relays for grounds and s. c. | Differential for grounds and s. c. | Checked by operators, and by syn. check relays at adjacent automatic reclosing station. | Low tension transformer bank breaker | Ground voltage relay | Has been in either direction; less to customer after boiler. |
| 2. | Power directional relays for grounds and s. c. | Differential for grounds and s. c. | "Out of syn." relay trips 22 kv bus tie breaker. | 22 kv bus tie breaker | Ground voltage relay | To customer. |
| 3. | Power directional relays for grounds and s. c. | Bus overload and grounds | "Out of syn." relay trips customer's gen. breaker. | Generator breaker | Ground voltage relay | To customer. |
| 4. | Power directional relays for grounds and s. c. | Differential for grounds and s. c. | "Out of syn." relay trips the 22 kv H. T. bank breaker. | High tension transformer bank breaker | Ground voltage relay | To customer. |
| 5. | Pilot wire relays with back-up power directional relays, all for grds. and s. c. | Differential for grounds and s. c. | Checked by operators, and by syn. check relays at adjacent automatic reclosing station. | 66 kv line breakers | Not cleared but sys. can be sep. by closing No. 1 brkr. and then opening Nos. 2 and 3 | To customer. |
| 6. | Power directional relays for grounds and s. c. | Differential for grounds and s. c. | Do not operate in parallel. | Do not operate in parallel | Do not operate in parallel | To customer. |
| 7. | Distance directional relays for grds. and s. c. | Differential for grounds and s. c. | Checked by operators, and by permitting only "dead line reclosing" at adjacent automatic reclosing station. | High tension bank breaker | Ground voltage relay | To customer at first. and later to D. L. Co. |



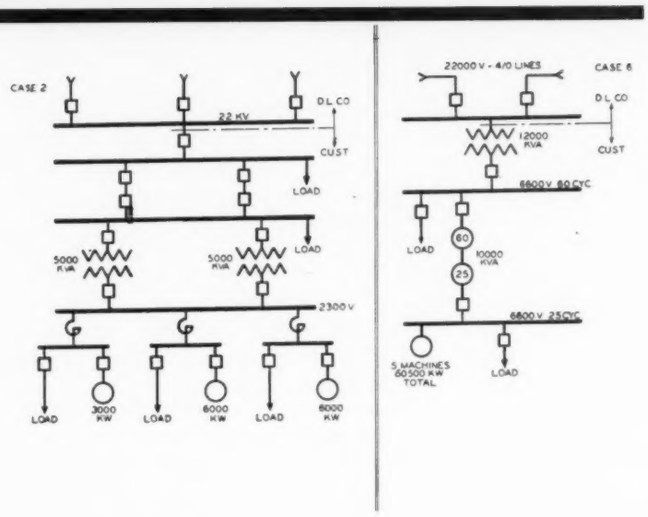




**Figure 2 — (left) Sketches showing connections for interconnections in cases 1, 3, 4 and 7.**

**Figure 3 — (above) Diagrams giving connections for interchange hook-ups in cases 2 and 6.**

with customer's 60 cycle generating units was made and is still in operation.

Figure 3 shows diagram of connections for this interconnection, and at first glance it appears to be quite a complicated set of switching, but is relatively simple after some study. The connections for these two 5000 kva banks, the frequency changer set, and the 25 cycle system are not shown, although parallel operation may be carried on with the three systems.

The short circuit values and breaker duties are shown in Table II and had to be calculated at the different busses so as to permit proper application of circuit breakers. Reactors were installed on each generator to limit the short circuits on customer's breakers.

While the industrial plant's generating capacity has not been, and will not be, sufficient to carry the entire load, the difference between the amount it can supply and its own load is of the order of several thousand kw. In event it is necessary to separate the two 60 cycle systems, it is done by opening the 22 kv bus tie breaker between the two 22 kv busses. The protective relaying required between the two systems is generally applied to this breaker.

The relay protection provided consists of power directional relays on the incoming utility company lines, differential protection on the high tension busses, out-of-synchronism relaying, and other necessary relay items — all as shown under case 2, Table III.

The Duquesne Light Company has a telephone line into this interconnecting substation.

### CASE 3

This is a relatively small interconnection, as the capacity of the industrial generator (installed in 1935) is only 1500 kw, compared to the customer's load of 8000 kw at times.

Figure 2 shows diagram of connections for the interconnecting substation at this plant, and Table II shows the short circuit values and the breaker duties.

In this case, the normal power supply is always from the utility company to the customer's 2300 volt bus. There was no problem of interrupting capacity of the circuit breakers in the customer's plant as a result of this interconnection, because the 10,000 kva bank supplying the 2300 volt bus was in service for a number of years before the 1500 kw generator was installed, and the contribution to the short circuit from the customer's generator was and is a relatively small part of the total, as can be seen from the short circuit data in Table II.

The relay protection consists of power directional relays on the utility company's incoming lines, bus overload and ground protection for the high tension bus, and other relay requirements as covered under case 3, Table III. Figure 5 shows schematic diagram of relay protection provided, together with a tabulation of the relay tripping table which shows the breakers tripped by each set of relays.

An interesting feature of this installation in connection with relay protection, is out-of-synchronism protection which is provided by relay No. 10. This relay has two sources: one from the 2300 volt bus to which the customer's generator connects and to which also is connected the power company's main supply; the other source is a single phase, 115 volt source from the 4 kv distribution system on the street nearby, which 4 kv system in turn is supplied from a Duquesne Light substation other than the Duquesne Light substation which supplies the incoming 22 kv lines to this customer's in-

dustrial plant. This relay will trip the customer's generator breaker when the two systems are out of synchronism.

### CASE 4

The Duquesne Light supplied power to this customer's industrial plants for a number of years, and then about 1928 the 600 kw generator was installed to serve additional load as an isolated 60 cycle system and to at the same time provide low pressure steam for plant purposes. Later, about 1933, the 1500 kw generator was installed and at that time the connection between the two systems was made as shown in Figure 2.

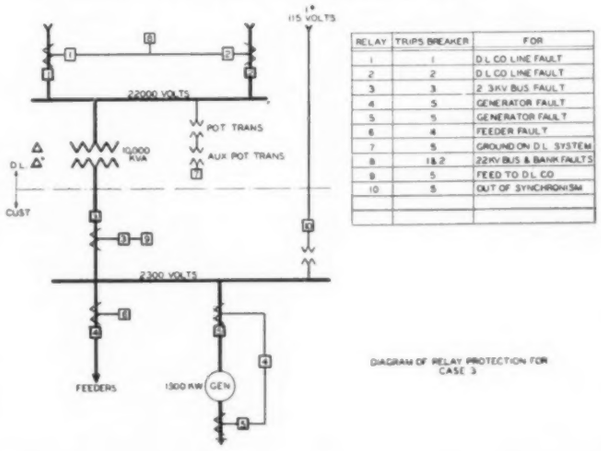
The short circuit duty is shown in Table II, and is not excessive, due partly to the length of the utility company's lines, and hence the large impedance. To our knowledge, no breaker replacements were made when the interconnection was made by reason of the interconnection. We understand that the 2000 kva bank will be replaced with a 5000 kva bank sometime in 1943 to provide for additional plant load. This bank replacement will materially increase the breaker duty on the 2300 volt side and possibly some breaker replacements will be required.

While this is an interconnection and the two systems operate in parallel, no power is normally taken from this plant by Duquesne Light, as the customer's generating capacity is insufficient for his entire load, and the Duquesne Light always supplies the difference. The larger bank will require still greater load from the Duquesne Light system.

The relay protection consists of power directional relays for short circuits and grounds on the incoming utility company high tension lines, differential and ground protection for the high tension bus, and other relay protection as covered under case 4, Table III. Out-of-synchronism relay protection is provided and is similar to that described for case 3.

The Duquesne Light Company has a telephone line into this interconnecting substation.

**Figure 5 — Schematic diagram of the relay protection provided for the interconnection of case 3.**




| RELAY | TRIPS BREAKER | FOR |
|---|---|---|
| 1 | 1 | D L CO LINE FAULT |
| 2 | 2 | D L CO LINE FAULT |
| 3 | 3 | 2 3KV BUS FAULT |
| 4 | 5 | GENERATOR FAULT |
| 5 | 5 | GENERATOR FAULT |
| 6 | 4 | FEEDER FAULT |
| 7 | 5 | GROUND ON D L SYSTEM |
| 8 | 1&2 | 22KV BUS & BANK FAULTS |
| 9 | 5 | FEED TO D L CO |
| 10 | 5 | OUT OF SYNCHRONISM |

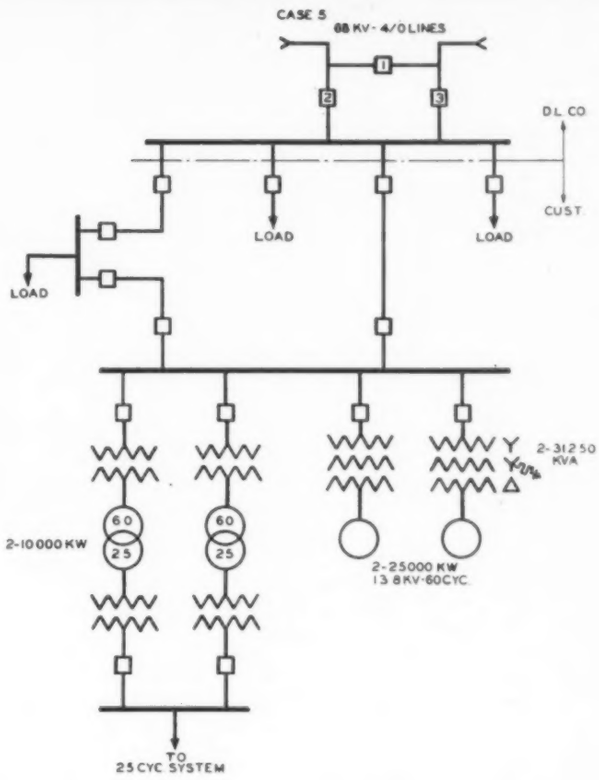



**Figure 4 — This new interconnection, of large capacity, presents high short circuit duties at some points.**

### CASE 5

This interconnection is expected to be in service in the middle of 1943 and will be a very large one, actually being the largest on our system.

Figure 4 shows the diagram of connections for this interconnection and includes the capacities of the customer's 60 cycle generating units. The distance in miles from the interconnection substation bus to the generating plant bus of the industrial plant is about 1.25 miles.

The short circuit duties are quite large at certain points of this interconnection, and are shown in Table II. This short circuit amounts to 1,166,000 kva at 68 kv on the connecting substation bus, and is slightly less than 500,000 kva on the 13.8 kv side of the step-down transformers in the 60 cycle generating station of the industrial plant. Such heavy short circuits are to be expected for an interconnection like this, as the two 4/0, 68 kv lines from the utility system are supplied directly from the backbone of the utility's main transmission ring.

The tie breaker between the two incoming utility company 68 kv lines is expected to be installed this year prior to the connecting in of the industrial plant's 60 cycle generating equipment, and is necessary to permit complete isolation of the two systems in the event of serious trouble on either one of them. This also permits the Duquesne Light 68 kv transmission lines at

this point to be kept tied together during trouble on the industrial system, a necessary procedure for the proper operation of the Duquesne Light system. This is accomplished by remote tripping of the two incoming Duquesne Light line breakers which are connected beyond this tie breaker by remote control by the system operator at the industrial plant upon instructions from the utility company's system operator. These line breakers are tripped with the 68 kv tie breaker closed.

All the 68 kv line breakers (both Duquesne Light and industrial) at the interconnection substation, which is unattended, are remotely controlled from the industrial plant's system operator's office in a nearby plant. The Duquesne Light breakers are operated only upon their (Duquesne Light) dispatching orders. Incidentally, this interconnection substation is located at a spot isolated from the plants of both companies.

An interconnection of this type requires very close co-operation among the managements, designers, and operators of the two companies, and to date although not actually in service, we are convinced that it will be successful throughout its existence. Naturally, the loading of the industrial plant generators and the stopping and starting thereof, together with synchronizing, will be at the discretion of the industrial plant, but of course keeping within the limits of the power company's requirements for power flow between the two systems.

An interesting feature of this interconnection is the 60 cycle to 25 cycle, tube type frequency changers which are to be operated as one-way frequency changers from the 60 cycle to the 25 cycle system, but which can be operated either way by merely making adjustments in the control. Power flow will be automatically regulated regardless of fluctuations of frequency within plus or minus ½ cycle. These frequency changers will be installed to bolster up the 25 cycle generating capacity.

All the 68 kv transmission lines in the immediate interconnection are protected by modern pilot wire relays so that faults on these circuits can be cleared in a minimum of time with a minimum of disturbance to both systems. The Duquesne Light pilot conductors themselves are supervised (checked for freedom from grounds and for complete continuity) several times a day by the operators at the adjacent utility company substation so as to have any necessary repairs promptly made.

The utility lines also contain back-up relay protection of the power directional type which functions in event of failure of the pilot conductors. It is necessary to coordinate this protection with the industrial plant's relay protection on its 68 kv lines. The bus of the interconnecting substation is protected by differential protection. Case 5 in Table III contains a tabulation of the relay protection provided for this interconnection.

Facilities for checking synchronism are provided at adjacent utility company's attended substation so that that operator will not reclose the Duquesne Light line breakers with the systems out of synchronism. Automatic reclosing facilities for a dead line only are provided on the two incoming Duquesne Light 68 kv line breakers at the interconnecting substation and this eliminates the necessity for the out-of-synchronism control at these locations.

Remote load indicating, and supervisory and tripping facilities are being provided from this substation to the load dispatchers' offices of both companies. To our operating people this is considered as just another generating source and therefore they must have knowledge at all times of the amount and direction of power flow over this interconnection.

Duquesne Light Company has a direct system operator's telephone line from its dispatching office to the customer's dispatching office and to the interconnecting substation. In addition, there is a Duquesne Light owned telephone circuit from their main office to the interconnecting substation via another major substation in this district. Further, the customer has telephone communication from his dispatching office in a nearby mill to the interconnecting substation. Both companies have Bell PBX board telephone systems which can be used to reach the interconnecting substation.

### CASE 6

Actually, while this is an interconnection, the two systems do not operate in permanent parallel operation. The scheme of operation is to have the utility system carry the 60 cycle load and the frequency changer set, with a block of the 25 cycle load isolated from the industrial plant's 25 cycle system; or to have the industrial plant carry the frequency changer set and the 60 cycle load through this set. No parallel operation is done, although attempts were made to operate in parallel for a short period of time to make this transfer; however, it was found to be more satisfactory to actually transfer the load without making the parallel connection. Usually the 60 cycle load is carried by the industrial plant in the summer and by the utility company in the winter, due to steam requirements upon the industrial plant in the winter. We are told that additional boiler capacity is being considered and may be in service this year, so that they will have more steam requirements for summer and winter.

Figure 3 shows diagram of connections for this interconnection, and Table II shows the short circuit values and breaker duties. This interconnection has been installed since about 1928.

The relay protection consists of power directional relays for ground and short circuits on the two incoming utility lines, and differential protection for the high tension bus for both grounds and short circuits. Case 6, in Table III, shows the relay protection for this interconnection.

In addition, an interesting relay feature in connection with the frequency changer set is a low frequency relay connected to the 60 cycle side arranged so that it will disconnect the 60 cycle side of the frequency changer from the 60 cycle bus if, after starting the set from Duquesne Light lines, the light company lines trip out, thus leaving the set coasting to rest. The time to coast to rest would be too long to wait for the utility company to restore service to its lines onto this bus, which lines supply other customers, and therefore this low frequency relay will trip the 60 cycle breaker of the set after the frequency drifts down several cycles. This will permit Duquesne Light to restore its 22 kv lines without giving this set a severe "bump."

### CASE 7

This plant is expected to be in operation sometime in 1943. Figure 2 shows the diagram of connections, and Table II shows the short circuit values and the breaker duties.

The extension to reach this industrial plant is a 1/0, 66 kv wood pole construction and is about 1½ miles long, being connected onto the utility company's 66 kv transmission system in this vicinity. The 13.8 kv system on the low tension side of the step-down bank is grounded at the bus through a grounding bank and a resistor, which is quite different from most of the other interconnections, as these industrial distribution systems are generally ungrounded.

Initially, the Duquesne Light Company will be supplying a considerable amount of power, approximately 16,000 kw, in advance of the completion of the industrial's generating plant. Then, after the customer's generating plant is in service, a 35,000 kw unit, the Duquesne Light will take the difference or about 19,000 kw into its system subject to the arrangement of mutually satisfactory terms.

Prior to the industrial generator being in service, the relay protection will consist of the usual overcurrent relays for phase and ground faults in the interconnection substation, together with differential protection around the bank for both phase and ground faults. This protection will operate to trip Duquesne Light 66 kv breaker.

After the customer's generator is in operation in parallel with the utility system, additional protection will be cut in service (although installed initially) to provide for tripping the incoming 66 kv line breaker for faults on the Duquesne Light's 66 kv system, by means of reactance type distance relays for phase faults. For temporary ground faults, no tripping of the 66 kv breaker is provided. For permanent ground faults on the Duquesne Light 66 kv transmission system in this vicinity, clearing of the fault from this customer's generator via the step-up bank is accomplished by tripping the 66 kv breaker by means of a zero sequence voltage relay connected to the 66 kv line with potential transformers, which is similar to the protection provided for cases 1, 3 and 4. Upon tripping the Duquesne Light 66 kv breakers at adjacent stations which supply this tie line, and with the industrial plant's generator feeding this line through the step-up bank, provision has been made at one adjacent Duquesne Light 66 kv station (unattended), which has an automatic reclosing breaker on this line, to prevent automatic reclosure of this breaker if the two systems are out of synchronism. At the other Duquesne Light 66 kv station, a power station, the operator verifies synchronism with the industrial plant before actually closing the breaker. Normally, the actual synchronizing is done at the industrial plant by orders from the utility company's system operator. Case 7 in Table III shows in tabulated form the relay protection for this interconnection.

Remote load indication facilities are being provided to show the amount and direction of power flow over the interconnection in the Duquesne Light system operator's office, as our operating forces feel that this interconnection is just another generating source and they must at all times know the amount of power flow over the interconnection, and the direction.

Duquesne Light Company has a direct system operator's telephone circuit to the interconnecting substation and to the generating station switchboard room of the industrial plant. We understand also that the customer is providing a telephone connection via their PBX board to the interconnecting substation and to their generating station switchboard room.

### CONCLUSIONS

We would like to say in conclusion, even though it is a repetition, that the following points include most of the important ones applying to interconnections between utility systems and industrial generating plants.

1. Excess waste fuel or heat from manufacturing operations which could be converted into electrical energy.
2. The installation and operation of 60 cycle motor-driven equipment in plants which generated 25 cycle or d-c electricity.
3. Possible power take-off from back-pressure turbo-generators installed to serve as reducing valves.
4. Desirable back-up from the utility's lines for overloaded stations or during the intervals when these stations were being expanded. In most instances, they have more than proven their worth for these reasons alone.

## DISCUSSION


PRESENTED BY

**A. G. DARLING, Industrial Engineering Department, General Electric Company, Schenectady, New York**

**W. B. FERGUSON, Electrical Engineer, Duquesne Steel Works, Carnegie-Illinois Steel Corporation, Duquesne, Pennsylvania**

**B. M. JONES, Duquesne Light Company, Pittsburgh, Pennsylvania**

**T. W. SCHROEDER, Application Engineer, General Electric Company, Schenectady, New York**


A. G. DARLING: Messrs. Jones and Dexter's discussion of interconnection between public utilities and steel plants is especially interesting since it related experience obtained over a period of years of successful operation and carries in it some very instructive information. In general, interconnection of utilities and industrial plants has proved quite satisfactory to both parties. A few cases have shown the need for better understanding of fundamental conditions.

In a few instances there has been evidence of lack of understanding of the possible operating characteristics of the particular industry involved. In one case, average consumption of steam extracted from the turbine, which the utility installed to furnish both steam and electricity to the industry, was used to determine the maximum ability of the turbine to furnish steam. The

industry's process required steam at high rates for short periods followed by longer periods at moderate rates. To meet the deficiency in short time capacity, it became necessary to by-pass the turbine, using boiler pressure steam. In a second case, the contract stipulated conventional rates for steam and electricity and also guaranteed that the cost of services would not exceed a given figure per pound of industry's product. Nothing was said as to the quality of the product so the industry proceeded to manufacture a much higher quality of product using appreciably more steam and electricity.

In answer to the questions that have been raised concerning the electronic converter that is to be furnished to an industry in this district, it should be said that Mr. Jones is correct in stating that the load through this converter is to be controlled to a constant value. The control is such that it will be possible to modify the flow of power from full load in one direction to full load in the opposite direction without switching primary circuits.

The electronic converter has a unique characteristic which seems particularly adapted to interconnections between steel mills and public utilities. The latter have frequencies in general which do not vary more than about one-quarter cycle above and below their normal frequency. Steel plants, on the other hand, frequently depend upon the flywheel effect of their rotating equipment to absorb high, short-time peaks which cause their frequency to change one-half and sometimes three-quarters of a cycle above and below normal. There are types of rotating frequency converters, such as the Scherbius converter, that allow these frequencies to continue to vary and still remain in control of the power flow. Both flexible and fixed ratio rotating converters have costs which increase with the departure from normal frequency ratio of the two systems. Contrasted with this characteristic of the rotating converter, the electronic converter does not respond to frequency changes but for a given load setting, transmits power as a function of the departure from normal voltage ratio of the two systems. Compensation for departure from normal voltage ratio can be accomplished by grid-shift control of the converter at relatively small expense. Likewise, within the designed limits of the converter, the load transmitted through it can be controlled to a nominally constant value even though the voltage ratio between the two systems changes independently or as a function of the load through the converter.

The value of reactive kva control of widely fluctuating steel mill loads, when they are simultaneously fed by local steel mill generation and by public utility sources of power, has been shown from an investigation of one interconnection. In this case, the local generators are under automatic voltage regulation which, to a degree, tends to hold relatively constant reactive kva drawn from the public utility. If the variable steel mill loads took a constant recactive kva, the generator voltage regulators would continue to hold the reactive kva drawn from the public utility at a relatively constant value.

It is, however, common practice to pre-adjust the excitation of the synchronous motors which carry the variable load to such a value as will permit these motors to carry their peak loads without exceeding their pull-out torque. This means that at peak loads the reactive kva drawn from the sources is at its minimum, whereas in a period of light load, the reactive kva is at a maximum due to their overexcited condition. When the local generator voltage regulators find that the voltage of the system is rising due to overexcitation of the motors, the regulators call for underexcitation of the generators.

The generator regulators tend to cause the generators to compensate for the changes in load rkva but since they operate as a function of voltage, do not hold constant rkva on the public utility.

The net result is that at periods of high load, the reactive kva in the underexcited condition drawn from the public utility is at a maximum and, at light load condition, the reactive kva in an overexcited condition is a maximum, — just the opposite from optimum circumstances. The variation in reactive kva, which in turn causes variation in supply voltage and consequential transmission line losses, fluctuations in resistance loads, etc., can and should be largely corrected by the use of reactive kva regulators on the motors supplying the fluctuating load.

Reactive kva control of variable loads fed by local generators without benefit of public utility connection has, in certain other cases, given more constant system voltage due to less oscillation of reactive kva between motor and generator.

**W. B. FERGUSON:** I would like to add one comment. I happened to be connected some years ago with one of the concerns which owned one of the small units referred to by Mr. Jones. This unit was the one referred to as being equipped with frequency check relays. I believe Mr. Jones said it had been the cause of kicking the generator off several times. The major number of these occurrences were during the 1936 flood, at which time we fed the Duquesne Light Company power. Most of these faults were caused by very unstable power system operating conditions.

My reason for commenting on this connection was to point out that in dropping the generator from the bus we did not loose the steam end, as the turbine was run on high back pressure and was automatically regulated, preventing the steam end from shutting down or even dropping speed very materially. It was therefore only a matter of some 30 seconds to 1 minute to get the generator back on the line under normal bus conditions.

If, however, the Duquesne lines went out, the generator could not be put back on the bus as the load was probably three times the capacity of the machine. Under these conditions we either took off non-essential load to reduce the bus to the machine capacity or awaited Duquesne Light Company's power restoration. I might add that since the 1936 flood the generator and relaying have been working very satisfactorily so far as I can learn.

If such a machine as the one mentioned depended on an over-speed governor to trip the steam end of the unit I would question the advisability of such a frequency checking system.

**B. M. JONES:** Mr. Darling said something, I believe, about using these frequency changers for tie line control where there is a connection between any two

electrical systems. Could they be used for 60 to 21 cycles instead of 60 to 25?

**A. G. DARLING:** For anything from 120 cycles down.

**B. M. JONES:** What I had in mind would be a difference of one about cycle, so I see that range of the electronic charger would be ample.

It was interesting to hear the comments on the fluctuating loads of steel mill plants. Mr. Darling talked about power factor on strip mill loads. When we first took a large strip mill several years ago, power factor devices were installed, and as sometimes happens were not working quite right, and the voltage would drop under heavy load. The two companies got together on the problem and when it was adjusted the voltage was held very close. The adjustment range was there all right and all that was necessary was to make it work. You said you could make adjustments to the electronic frequency sets over an appreciable range.

Mention was made of the 1936 flood. Conditions were pretty turbulent at times, and we took all the power we could get from any place. As you men may not recall, we carried our load until within one foot of the crest; Colfax power station went out at 45 feet and the crest was 46 feet. Since then we have made considerable improvements, such as moving vulnerable accessory equipment to a higher level and can carry our load with considerably more water now than in 1936, so that we are not so much concerned over a 46-foot flood any more. There was only one substation flooded in the 1942 flood.

The United States government flood control program is expected to reduce the flood stage at the point in Pittsburgh by 3 feet for similar precipitation and runoff conditions in the head waters.

**MEMBER:** How much investment was involved in that rehabilitation work?

**B. M. JONES:** About $1,250,000.00 total for damage, repairs, improvements, etc.

**T. W. SCHROEDER:** I am very interested in this topic. Messrs. Jones and Dexter have presented specific details regarding the general problem of interconnection with which I am acquainted only in very general terms. It is quite interesting to me to hear that seven interconnections shown in the tabulation were made in general because of the relatively cheap by-product power which the industrial could produce, and that they really "paid their freight" later on when the industrial needed peak or emergency power.

I would be interested if Mr. Jones would care to comment on arrangements for reactive kva or kilovar flow during the time kilowatts are flowing from the industrial to the utility, and vice versa. Mr. Darling mentioned something about the need for the control of power factor at the time the industrial plant requires a heavy kilowatt load. It is my feeling that in general steel mills abound in "kilovar generation." Is this of advantage in any way to the utility?

With regard to stability of the interconnections, I believe Mr. Jones pointed out, in general, that it was no particular problem except in the case where industrial generation was small compared to industrial load. I assume that quick switching of faulted lines is employed to maintain stability.

**B. M. JONES:** I haven't an exact check on the kilovar arrangements. When checking one of these contracts, we found as the operation progressed over a period of years, that it was not drawn quite the way it should have been with respect to kilovars and we re-wrote it. It had been a sort of handicap on operation of the interconnection. We re-wrote it so as to make the other party "come up to scratch," so he would not burden the party on the other side. You can get into no end of difficulty by failing to work out every problem you can think of, or somebody will get trimmed on it. You cannot just stumble along on kilovars.

Relative to stability, I did not mean to imply there was no stability problem with large generators, because very definitely there is. In general, the switching out of faulted lines or equipment is very fast, being about 12 cycles or less on 66 kv interconnections, and from 18 to 72 cycles on the 22 kv interconnections, depending upon the fault location.

**T. W. SCHROEDER:** Specifically in the case of the industrial plant that had a small generating plant and a large load, in case a fault occurs on the tie between the utility and industrial, the small industrial plant would be left with a big load if the tie is tripped out; hence, you are anxious to keep the tie in. In that case do you quickly reclose the tie?

**B. M. JONES:** I will have to explain. The two incoming 22 kv lines are set to trip in 15 and 54 cycles, respectively; usually one is "faulted" at a time. However, in event of total interruption of the company's supply, the 1500 kw generator will be left to carry the entire load and its breaker will be tripped in about 15 cycles after the supply is interrupted, by means of the "out-of-synchronism" relay. The steam end remains in service and it is only a matter of a short time to reclose.

There is another interconnection which I would like to describe very briefly but which is not an industrial interconnection, and will definitely be temporary. This is the interconnection between the Duquesne Light Company and a floating power plant now being built on a barge on the Monongahela River in the city of Pittsburgh. This floating power plant will consist of one 30,000 kw 13.8 kv gas or oil fired steam-turbine-generator with a 37,500 kva step-up transformer bank to make available high tension voltages of 69, 115, and 138 kv. There is no high tension circuit breaker on the floating power plant but there is a 13.8 kv generating breaker between the generator and the step-up bank. There will be two 300 kw turbine generating units driven by diesel engines for station service. As we understand it, these floating power plants will be completely independent and can start up anywhere so long as they can get fuel.

There will be four of these floating power plants equipped at this site of the Monongahela River and the plan is to tow them after completion to a point in the Ohio River opposite Brunot Island and connect them into the Duquesne Light system for tests of short duration through a 66 kv testing station consisting of a short 66 kv line, an oil circuit breaker, lightning arrestors, relay protection, control and metering. Natural gas will be used for fuel during the tests.

We understand that these floating power plants are to be used in various locations where power is not available for the war effort, or where power may be required in an emergency by anchoring it at the nearest site and connecting into the electric system as required.

# AMPLIDYNE *Control* FOR ADJUSTABLE *Voltage Drives*

***. . . . adjustable voltage control is now widely used for many heavy duty d-c rolling mill auxiliaries . . . . the use of the amplidyne exciter simplifies these control systems materially . . . .***

*by C. B. Huston*

INDUSTRIAL ENGINEERING DEPT.

GENERAL ELECTRIC COMPANY

SCHENECTADY, NEW YORK

▲ IT IS generally recognized that the adjustable-voltage type of control has several advantages over the magnetic constant-potential type still frequently applied to heavy-duty, direct-current rolling-mill auxiliaries. These advantages are:

1. Reduction in wear and tear on control devices.
2. Higher rates of acceleration and deceleration because torque is applied uniformly.
3. Definite current limit up to motor stalling point.
4. Higher ultimate speeds possible by applying overvoltage to the mill motors (most designs are good for double voltage).
5. Reduction in wear and tear on mechanical equipment because of the smooth application of torque.

To make these advantages available, the well-known "three-field," or shovel-type, generator has been used successfully for some time, since it provides such desirable features as high speeds at light loads and stalled-motor protection. The advent of the amplidyne, a new aid to control, offers still further advantages. By no means limited to mill auxiliaries, the amplidyne is applicable to many other motor applications.

Through the use of the amplidyne, the control system for adjustable-voltage drives has been simplified and the devices needed have been reduced both in size and number. Furthermore, this new system makes the motor fulfill the following functions up to design limitations.

1. Control of voltage through any range to suit the speed required by the drive.
2. Control of current value at which the motors may be stalled, if it becomes necessary to deliver the maximum torque.
3. Control of current value at which the maximum rate of acceleration of the drive will be maintained.
4. Control of current on pump-back for stopping.
5. Control of current on plugging, keeping it comparable with that for stalling.

Figure 1 shows an elementary connection diagram of the complete armature, field, and control circuits. The generator is excited by the amplidyne and the control circuits handle only the very small currents required by the various control fields of the amplidyne. The armature circuit is a closed loop.

## OPERATION

The operation of the control system can best be described by reference to the vectors shown in Figure 2, which reveal the magnitude and relationship of the various control fields of the amplidyne. The principle involved is that of balancing the strength of one field against the strength of another. The difference in strength is used to produce the necessary excitation for the system.

*How voltage is controlled* — The vector, RF, represents the reference field, F3-F4, which is energized in either one direction or the other, for a reversing drive, from a constant potential control bus. This field provides the excitation to raise voltage on the generator and is adjusted at a value several times greater than that required (see section A of Figure 2).

VF is the vector of the voltage-control field, F1-F2, which is excited from the armature of the main generator to be controlled. This field opposes the reference field and pushes the voltage downward. When the generator voltage rises to the point where the difference in strength between RF and VF is sufficient to sustain excitation on the system, a balance is established and the voltage is regulated at this value. To hold different values of voltage, more or less resistance is inserted in

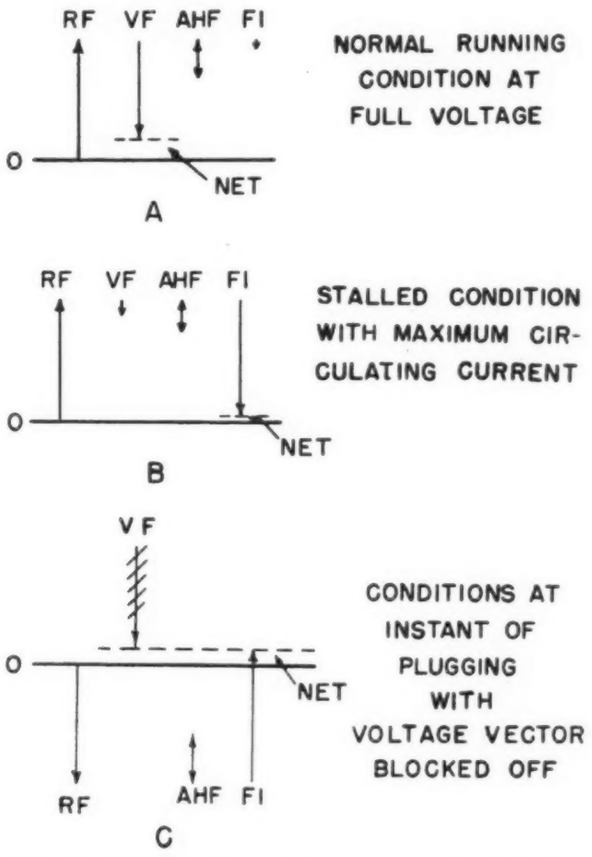
series with the voltage control field, causing the voltage to rise or fall until a balance is re-established.

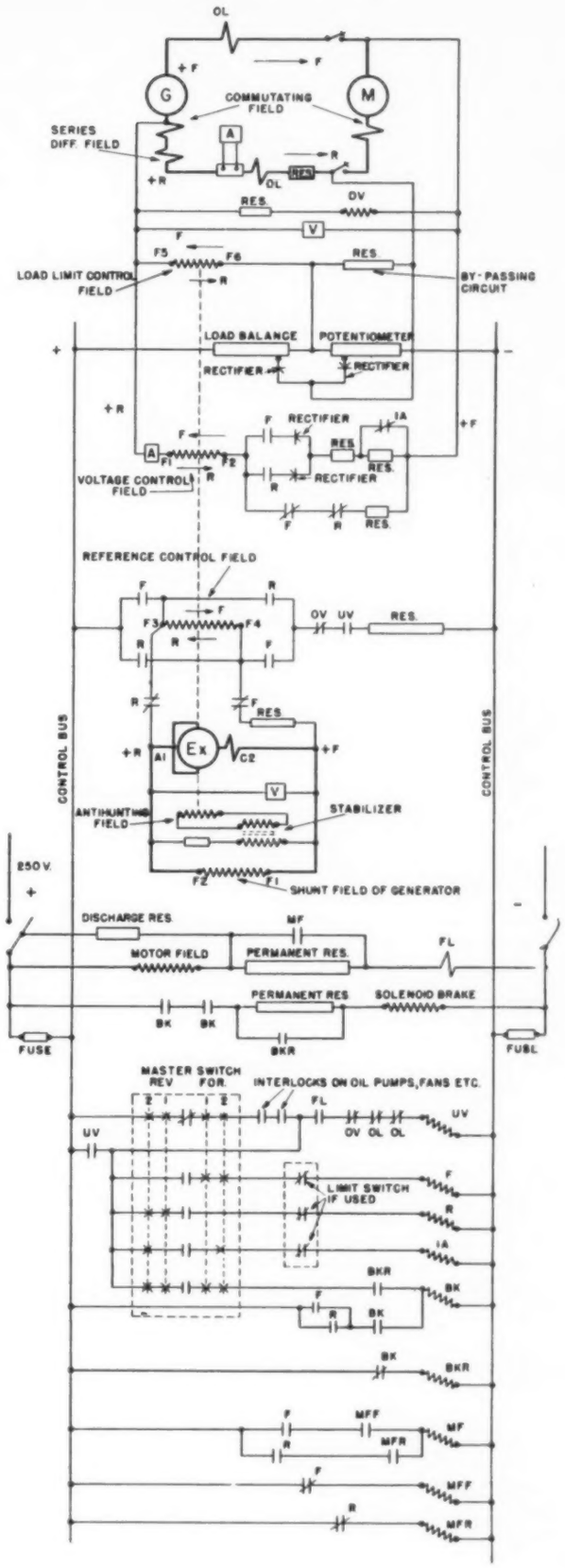
Vector AHF is the anti-hunting field, F7-F8, which is energized from the secondary of the stabilizing transformer whose primary is connected across the armature of the amplidyne. On sudden changes of amplidyne voltage, an impulse is transmitted through the transformer to counteract the change. This field is, therefore, free to act in either direction at all times. Its effect is adjusted with resistance in series with the primary of the transformer to the point where stability is obtained.

*How current limit is obtained* — The fourth and last control field of the exciter is the current-limit control field, F5-F6, which is represented by vector FI. This field is connected between two voltage sources — (1) the voltage drop across the commutating windings of the generator and motor, or, as is sometimes the case, line resistance; and (2), points on a potentiometer resistor, supplied from the main control circuit. By means of rectifiers in series with the field the proper polarity is maintained for either direction of rotation of the main drive motor and the current is prevented

**Figure 1 — (right) Elementary connection diagram of adjustable voltage control system with amplidyne, showing complete armature, field and control circuits.**

**Figure 2 — (below) Vectors showing relative magnitude and relationship of control fields for adjustable voltage control using an amplidyne exciter.**



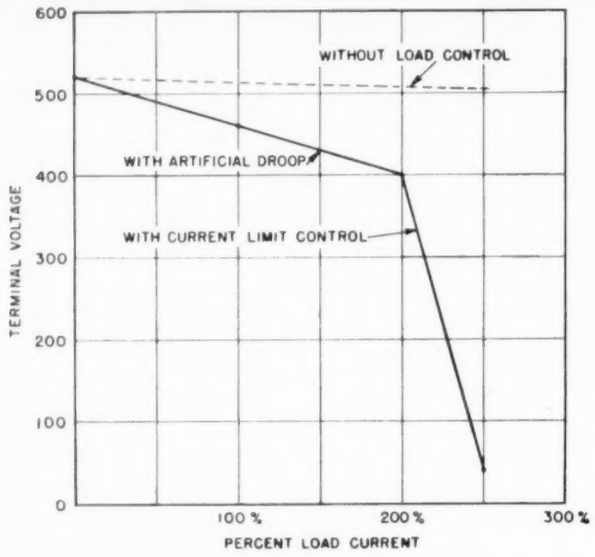



**Figure 3 — Theoretical volt-ampere characteristic curve for adjustable voltage control system with amplidyne.**

from flowing backward from the potentiometer. It is only after the voltage drop from the main armature circuit exceeds that across the points selected on the potentiometer, that current will flow and this field become active.

Note that the current vector FI (section B of Figure 2) is in the same direction as that of voltage vector VF. Therefore, when the current control becomes active, it supplants the ampere turns of the voltage control field and thus causes the voltage to decrease. This process may continue up to the point where the motor stalls, since only sufficient voltage remains to circulate the current in the armature circuit.

*Control of plugging* — An important feature of this control is that the current peak on plugging is limited to substantially the same value as that set for stalling. Referring again to Figure 1, note that there is a set of directional rectifiers in series with the voltage control field, one for the forward direction and the other for the reverse direction. When the drive is to be plugged, that is, when the control circuit is to be reversed suddenly, a change in the selection of the rectifiers in the voltage field is made simultaneously with the reversing of the reference field. Therefore, current is momentarily cut off from the voltage control field until the voltage of the generator passes through zero and starts to build up in the opposite direction.

Referring to section C, Figure 2, note that at the instant of plugging, the voltage vector, VF, and the reference RF, are both in the same direction. Since, however, the voltage vector is momentarily blanked out, the current field need overcome no more than the reference field plus a small amount in excess to sustain, if necessary, the flux in the previous direction. In this way, the plugging current is limited to a value only slightly in excess of that for stalling.

*Field forcing* — To what degree forcing is available from the reference field to cause the voltage to rise rapidly has already been pointed out. When plugging, the reference field is reversed; this again forces a voltage decay as well as a build-up in the opposite direction. When stopping the drive, some form of forcing must still be used to remove voltage quickly from the generator and to make the rate of retardation sufficiently fast.

It will be remembered that the voltage control field which is energized from the voltage of the generator is excited in a direction that forces the voltage downward. Therefore, if the effect of the voltage control field is increased when the master switch is centered, the voltage will decay more quickly. To accomplish this, directional relay contacts close when the directional relays open and, with the proper resistor, complete a circuit which by-passes the resistance normally in series with this field. The voltage of the amplidyne quickly reverses and forces the field of the generator to decay. At the same time, the amplidyne's reference field is connected to its own armature in a differential direction. By adjusting the resistors in these two circuits, the voltage of the amplidyne may be caused to return to zero at about the same time that the voltage of the main generator subsides. The drive thus is brought to rest quickly.

## OPERATING CHARACTERISTICS

From the description given above it can be seen that as long as the current-limit zone is not reached, the voltage control field has full sway to regulate the voltage at whatever value it may be set. This is true, within close limits, irrespective of the load being carried. This characteristic is highly desirable for some drives such as run-out tables for hot-strip mills where the speed must match closely that of the mill equipment that it serves.

For many other drives, the voltage should droop with the load. For instance, on the screwdown, live tables, and manipulators on blooming and slabbing mills, as well as for use on some shears associated with such mills, 230-volt mill-type motors are operated at voltages considerably higher than normal. At zero load, the voltage permissible on the generator may be as high as 500 volts; but when load comes on, the voltage should droop gradually to the cut-off point where the current control overcomes the opposition of the potentiometer and assumes full control, as shown in Figure 3.

The drooping characteristic is obtained easily with a resistor circuit which by-passes the potentiometer. The current control thus becomes effective to a mild degree at the very beginning. The amount of droop may be adjusted by varying the resistance in the by-pass circuit. Beyond the point of cut-off, it is desirable to force the voltage downward on as steep a slope as is possible. The limit here depends upon the relative strength of the current control field to the reference field, and the amount of resistance in the by-passing circuit. Naturally, the current-control field is made quite powerful as compared to the other, and the resistance is held to a minimum value.

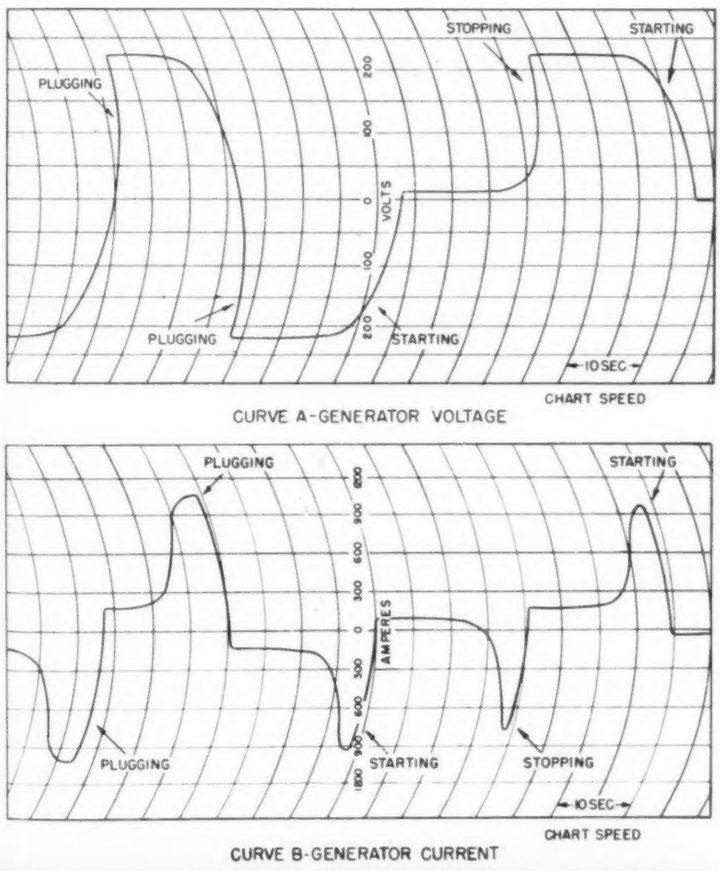
A differential series field is recommended for the generator. This will have a beneficial effect in:

1. Reducing current peaks on transient changes;
2. Assisting in wiping out the residual voltage on the main generator;
3. Assuring proper load division between two generators operating in parallel.

However, since a differential series field slows up the rate of flux change in the generator, it should be used mildly; from 8 to 10 per cent of total ampere turns is found sufficient. It is for this reason that the "three-field" generator and its control are not expected to be as "snappy," that is, not as responsive to control changes, as is the amplidyne system.

The adjustable-voltage control system implies the use of shunt-wound motors. In the auxiliary mill-type motor design, the normal continuous rating of the shunt field may be considerably below the maximum flux capacity of the machine. Therefore, the full torque of the motor cannot be realized unless some form of motor field forcing is used. It is possible, through the use of separate exciters or boosters, to automatically raise the excitation of the motor in direct response to the load current. However, a system of this sort involves additional complications which thus far have not been justified.

**Figure 4 — Graphic charts of voltage and current taken on run-out table drive.**



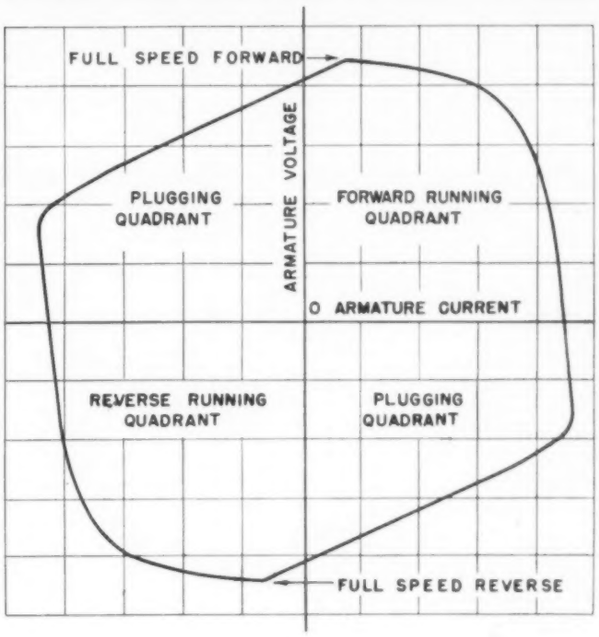




**Figure 5 — Operating volt-ampere characteristic curve (from data in Figure 4) for adjustable voltage control.**

The method used instead is to design the motor field for a low voltage drop and connect a permanent resistance in series with it. On the instant of starting, this resistance is short circuited for a short period. This gives the motor a boost in flux for the initial starting and assures the maximum torque for breakaway.

Field forcing may not be advantageous with the industrial type of shunt-wound motor since this inherently operates closer to the point of saturation. Therefore, the application of the motor field forcing is influenced by matters other than this particular scheme of control.

## GRAPHIC RECORDS

Figure 4 shows graphic charts of voltage and current taken on a run-out table drive, consisting of thirty-two 5-hp motors each direct connected to a roll. The groups are operated in common as a unit. Power is supplied by two 75-kw generators operating in parallel. The control for the generators is of the amplidyne type.

Curve A is of the generator voltage and curve B of the generator current. The current-limit setting is not quite reached when starting from rest or when stopping from full speed. In plugging from full speed in one direction to full speed in another direction, the current-limit control definitely comes into play.

The volt-ampere characteristic of this drive has been plotted from data taken from curves A and B, and is shown in Figure 5. It is interesting to note how closely the pattern of the accelerating portion of this curve resembles the theoretical curve of Figure 3, and also how little the plugging current exceeds the accelerating current.

There have been built recently or are now being built,

approximately forty adjustable-voltage rolling mill control systems of the type described above for use in rolling mills. These have been applied to services such as:

Screwdowns for blooming mills.
Side guard manipulators for blooming mills.
Live tables for blooming mills.
Bloom and slab shears.
Front and back tables for plate mills.
Table run-out in hot strip mill.
Pouring reels in rod mill.
Auxiliary follow-up tables.
Feed to hot metal saws.

The control details of the above applications have varied structurally because of the different requirements of the users, some, for example, having an elaborate transfer scheme to shift the generators from one control to another. Figure 6 shows a layout of the control panel for a simplified equipment where one generator serves one motor with no transfers but with line switches and lockout devices.

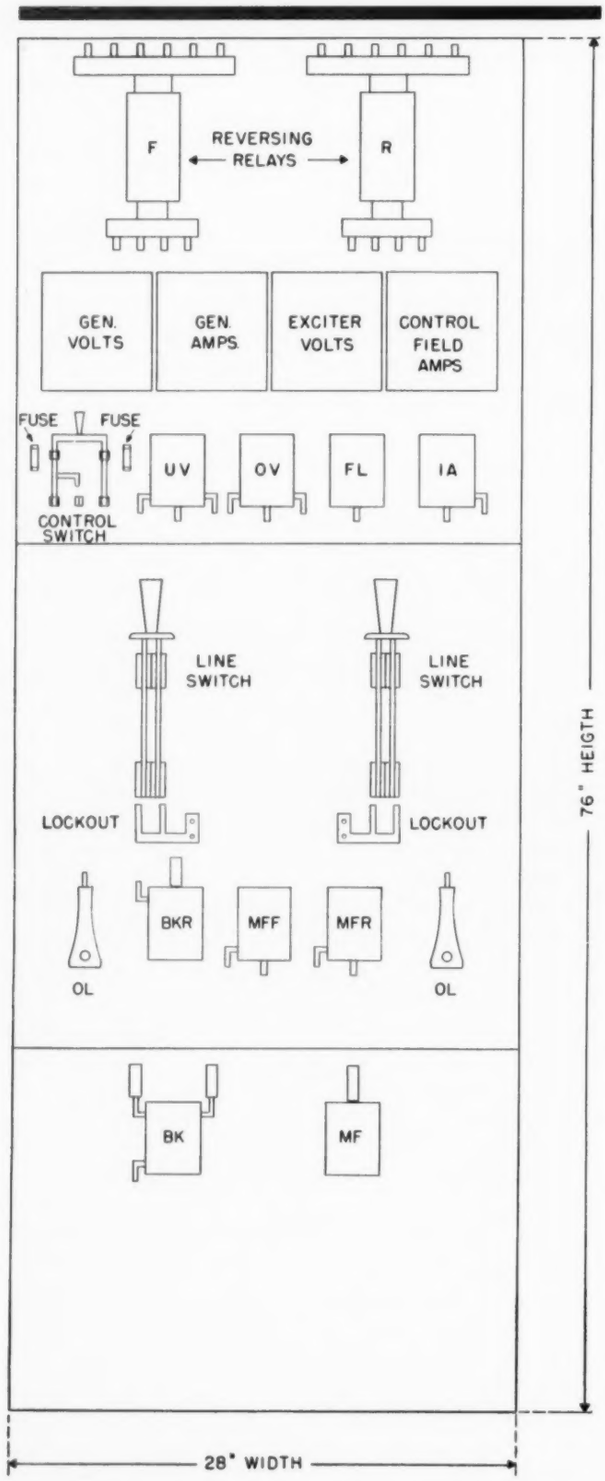



**Figure 6 — Front view layout of control panel for adjustable voltage control system using the amplidyne.**

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# Modern Turbine -

# TYPES AND DESIGN

***. . . . an analysis of new turbine installations shows that the steel industry is gradually following developments which have been tested and proven in the utilities field . . . .***

*by F. K. Fischer*

CENTRAL STATION STEAM ENGINEER

**Westinghouse Electric and Mfg. Company**

PHILADELPHIA, PENNSYLVANIA

▲ USEFUL and practical development of the steam turbine has taken place within the last fifty years, although practically every modern turbine principle was discovered much earlier. During this fifty year period, there has been continuous development of the steam turbine. A factor of utmost importance to this development has been the progress made in related equipment[1]: steam generators capable of operating at high pressure and temperature; electric generators to operate at the speed and capacity to match those of the turbine; condensers to sustain the low exhaust pressure to which the turbine is capable of expanding the steam.

Figure 1 summarizes the progress in operating conditions from 1900 to 1942. From thermal studies it was known that increasing the initial steam pressure and temperature would result in improvement in operating economy. However, the materials available, our knowledge of their physical properties, and the known methods of processing them to obtain necessary physical characteristics have always limited the maximum temperature for which turbines could be applied. Therefore, the curve showing the progressive increase of initial steam temperature with the years can also be considered as a plot of the progress and development in the art of metallurgy.

Increasing pressure has necessarily depended on increase in temperature, because increase in pressure alone results in excessive moisture in the turbine exhaust[2], with resulting loss in efficiency and excessive erosion of the last rows of turbine blades. High initial pressure with relatively low initial temperature is possible if interstage heating (reheating) is resorted to. The use of the reheat cycle is indicated by the use of initial steam conditions of 1250 psi gauge and 750 F total temperature. However, the boiler complications and necessary piping to reheat the steam at a relatively low pressure have seriously limited the use of this cycle.

The gains made by increasing steam conditions are attested to by the continuous decrease in the turbine heat rate. The heat rate has benefited from other factors also, such as: the increase in size of units, improvement in our knowledge of the proper design of blade path, and adoption of the regenerative feed heating cycle. The regenerative feed heating cycle[3] is responsible for the sharp breaks in the turbine heat rate (Figure 1) shown in the early 1920's.

## TURBINE OPERATING SPEEDS

The increase in maximum capacities of units at three different operating speeds is indicated. These capacity curves apply to single shaft units only. They are most significant in that they represent the rise and decline in popularity of turbine generator units for the different speeds of rotation. Once a given capacity can efficiently be built for reliable operation at a higher rpm, the lower rpm unit for that rating is definitely dated. To appreciate this, consider the following[1]:

The weights of geometrically similar turbines vary inversely as the cube of the speed and the capacity of such turbines vary inversely as the square of the speed. Therefore, the weight per kw of such turbines, in such a comparison, will vary in inverse proportion to the speed. Thus, for geometrically similar turbines, halving the speed gives four times the capacity but twice the weight per unit of capacity.

Therefore, the high rpm unit represents a considerable reduction in weight per unit of capacity. This reduction in weight of the higher rpm units is due to shorter bearing span, lighter rotor forgings and lighter (thinner walled) cylinder castings. The tabulation below gives a comparison on a percentage basis of a 60,000 kw, 3600 rpm unit with a 60,000 kw, 1800 rpm unit.

Presented before A. I. S. E. ANNUAL CONVENTION, Pittsburgh, Pa., Sept. 22-24, 1942

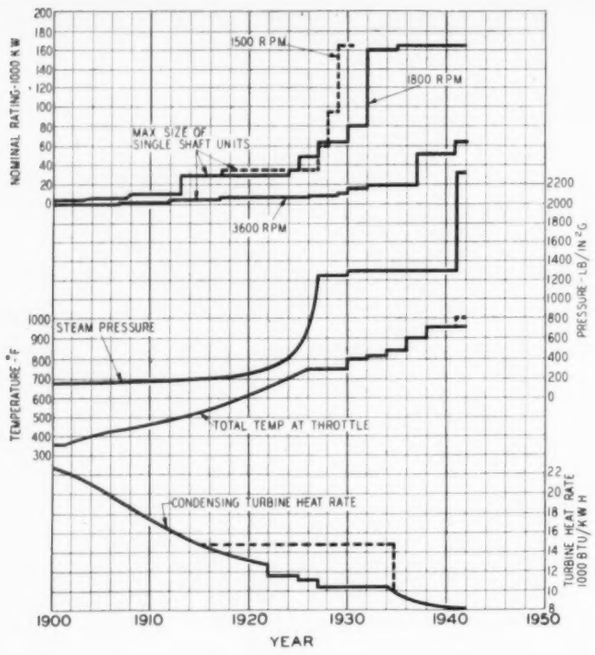



**Figure 1 — Progress in steam turbine operating conditions, 1900 to 1942.**

## COMPARISON OF WEIGHTS OF TURBO-GENERATOR UNITS

| Turbine element | 3600 rpm turbine | 1800 rpm turbine |
|---|---|---|
| Turbine rotor | 100 per cent | 250 per cent |
| Turbine cylinder | 100 per cent | 150 per cent |
| Generator rotor | 100 per cent | 150 per cent |
| Generator stator | 100 per cent | 75 per cent |

The problem of thermal expansion of parts, especially differential expansion due to non-uniformity of heating has always presented one of the major turbine design problems. Therefore, with the trend of increasing pressure and temperature of the last ten years it is only natural that the inherent advantages of the higher rpm unit should have given the necessary stimulation to obtain the development of larger capacity 3600 rpm units as shown by Figure 1.

## MODERN TURBINE PRACTICE

A review of steam turbine progress shows that it has taken place in very definite cycles which have been repetitive. The first step in the cycle is the development of necessary materials, design fundamentals and details. The second step is the commercial installation of new units incorporating the new materials and design features. These first units, then, receive the ultimate test of practical operation, unforeseen problems are encountered and designs are modified accordingly. The third and final step in the cycle is the stabilization of conditions for a period, while experience and development is accumulated to start the next cycle. The modern turbine is in the third step of this cycle today. Designs are fairly standardized. Units or elements necessary to make up units have had sufficient field experience so that the unforeseen problems and modifications have been successfully encountered. The general experience is that the modern 3600 rpm unit equals in efficiency, reliability, and sustained performance[4] the 1800 rpm unit which it has largely replaced in sizes up to 60,000 kw. condensing capacity. The necessary modifications to adapt the 1800 rpm unit to the highest modern pressures and temperatures have been successfully developed and where system capacity justifies condensing units above 60,000 kw. the 1800 rpm unit is normally used.

Modern turbine types and the capacities for which they are normally used today can be classified fairly accurately as follows:

1. Condensing units up to and including 60,000 kw are generally 3600 rpm.
2. Condensing units above 60,000 kw are generally 1800 rpm.
3. Non-condensing units are 3600 rpm.

A clear picture of modern practice can be obtained from a review of the orders placed for turbine generator units, 10,000 kw and larger, by industries (largely central station) during the one year period from October 1940 to October 1941.[5] These orders represent some 3,825,000 kw of capacity divided among 104 turbine generator units. A tabulation of these units is given in Table I. A review of this tabulation gives some very interesting facts, which show modern accepted practice and indicate trends.

1. More units of 25,000 kw rating were purchased than of any other capacity. In order of popularity the three most popular ratings are:

25,000 kw — 19 units — 18.3 per cent
35,000 kw — 13 units — 12.5 per cent
50,000 kw — 12 units — 11.5 per cent

2. The 850 lb pressure class is by far the most popular. Over 45 per cent of the units purchased were in this class.

3. The 900 F temperature class is over three times as popular as any other temperature rating. Approximately 55 per cent of the units purchased were in this class.

4. 80 of the units purchased, or 77 per cent, will operate at 3600 rpm. Only 14.4 per cent will operate at 1800 rpm.

5. In all ratings up to 60,000 kw, 3600 rpm units have practically replaced 1800 rpm units.

6. Hydrogen cooled generators are used in 60.6 per cent of the units purchased. This hydrogen cooling represents 74.6 per cent of the capacity purchased.

7. No units below 20,000 kw have hydrogen cooled generators.

8. Of the 69 units for ratings over 20,000 kw, 59 or 85.6 per cent use hydrogen cooled generators.

9. Of the 11 units purchased for 20,000 kw rating, four are hydrogen cooled. This size unit is the dividing line between air and hydrogen cooled generators. Below this rating all generators are air cooled, above it generators are largely hydrogen cooled.

## TABLE I — Turbine-Generator Units 10,000 kw and above Purchased During Year, October 1940 to October 1941

| Size in kw | | 10,000 | 12,500 | 15,000 | 20,000 | 25,000 | 30,000 | 35,000 | 40,000 | 50,000 | 60,000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of each size | | 12 | 4 | 8 | 11 | 19 | 4 | 13 | 4 | 12 | 4 |
| Total kw in each size | | 120,000 | 50,000 | 120,000 | 220,000 | 475,000 | 120,000 | 455,000 | 160,000 | 600,000 | 240,000 |
| Pressure psi gauge | 450 and lower | 2 | 1 | 2 | 5 | 1 | 2 | .. | .. | 2 | .. |
| | 451—650 | 8 | .. | 3 | 2 | 6 | .. | 2 | .. | 2 | .. |
| | 651—850 | 1 | 2 | 2 | 3 | 10 | 2 | 10 | 2 | 7 | 2 |
| | 851—1450 | 1 | 1 | 1 | 1 | 2 | .. | 1 | 2 | 1 | 2 |
| | 1451 and above | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| Temp. in degrees F | 750 and lower | 5 | 1 | 2 | 4 | 1 | 2 | .. | .. | 2 | .. |
| | 751—825 | 7 | .. | 4 | 3 | 4 | .. | .. | .. | 1 | .. |
| | 826—900 | .. | 3 | 2 | 4 | 13 | 2 | 11 | 3 | 8 | 4 |
| | 901—950 | .. | .. | .. | .. | 1 | .. | 2 | 1 | 1 | .. |
| | 951—1000 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| Speed in rpm | 1500 | .. | .. | .. | 1 | .. | 1 | .. | .. | .. | .. |
| | 1800 | .. | .. | .. | 1 | .. | 1 | .. | .. | 4 | 3 |
| | 3600 | 12 | 4 | 8 | 9 | 19 | 2 | 13 | 4 | 8 | 1 |
| | 1800 L. P. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| | 3600 H. P. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| Generator coolant | Hydrogen | .. | .. | .. | 4 | 19 | 2 | 13 | 4 | 9 | 1 |
| | Air | 12 | 4 | 8 | 7 | .. | 2 | .. | .. | 3 | 3 |
| Turbine type | Condensing | 10 | 1 | 6 | 11 | 17 | 4 | 13 | 4 | 12 | 4 |
| | Non-condensing | 2 | 3 | 2 | .. | 2 | .. | .. | .. | .. | .. |

| Size in kw | | 75,000 | 80,000 | 85,000 | 150,000 | Total No. | Per cent | Total kw | Per cent |
|---|---|---|---|---|---|---|---|---|---|
| Number of each size | | 2 | 3 | 5 | 3 | 104 | 100.0 | 3,825,000 | 100.0 |
| Total kw in each size | | 150,000 | 240,000 | 425,000 | 450,000 | | | | |
| Pressure psi gauge | 450 and lower | .. | .. | .. | .. | 15 | 14.4 | 347,500 | 9.1 |
| | 451—650 | .. | .. | .. | .. | 23 | 22.1 | 485,000 | 12.7 |
| | 651—850 | 2 | 2 | .. | 2 | 47 | 45.2 | 1,945,000 | 50.9 |
| | 851—1450 | .. | 1 | 4 | 1 | 18 | 17.3 | 962,500 | 25.1 |
| | 1451 and above | .. | .. | 1 | .. | 1 | 1.0 | 85,000 | 2.2 |
| Temp. in degrees F | 750 and lower | .. | .. | .. | .. | 17 | 16.3 | 357,500 | 9.4 |
| | 751—825 | .. | .. | .. | .. | 19 | 18.3 | 340,000 | 8.9 |
| | 826—900 | 2 | 3 | .. | 2 | 57 | 54.8 | 2,367,500 | 61.9 |
| | 901—950 | .. | .. | 4 | 1 | 10 | 9.6 | 675,000 | 17.6 |
| | 951—1000 | .. | .. | 1 | .. | 1 | 1.0 | 85,000 | 2.2 |
| Speed in rpm | 1500 | .. | .. | .. | .. | 2 | 1.9 | 50,000 | 1.3 |
| | 1800 | 2 | 3 | .. | 1 | 15 | 14.4 | 970,000 | 25.4 |
| | 3600 | .. | .. | .. | .. | 80 | 77.0 | 2,080,000 | 54.4 |
| | 1800 L. P. | .. | .. | 5 | 2 | 7 | 6.7 | 725,000 | 18.9 |
| | 3600 H. P. | .. | .. | .. | .. | .. | .... | ..... | .... |
| Generator coolant | Hydrogen | .. | 3 | 5 | 3 | 63 | 60.6 | 2,855,000 | 74.6 |
| | Air | 2 | .. | .. | .. | 41 | 39.4 | 970,000 | 25.4 |
| Turbine type | Condensing | 2 | 3 | 5 | 3 | 95 | 91.4 | 3,687,500 | 96.4 |
| | Non-condensing | .. | .. | .. | .. | 9 | 8.6 | 137,500 | 3.6 |

10. Seven units are being built with 3600 rpm high pressure turbines and 1800 rpm low pressure turbines.

In Table II is tabulated a resume of the turbine generator units purchased by steel companies during the past five years. From this it is evident that the steel companies are not purchasing for the steam temperatures and pressures which are common in the central station industry. This is perfectly logical for the production of power is not the primary function of a steel company and they cannot economically justify being pioneers in the power generation field. However, from this tabulation we see that steel companies are starting to adapt the non-condensing units at modern pressures and temperatures, also that 3600 rpm units predominate in this tabulation. With the operating record of the 3600 rpm units established and reliability of these high pressure and temperature units amply demonstrated, it is only logical to expect that the 3600 rpm unit with the popular pressures and temperatures found for central station units will be the type of unit used by the steel companies in the future. The exception to this will be those cases where waste heat boilers make the higher pressures and temperatures uneconomical.

### TURBINE ROTOR FORGINGS

The longitudinal section through a 12,500 kw, 3600 rpm, single cylinder condensing turbine for steam conditions of 850 lb gauge and 825 F total temperature, is shown in Figure 2. This turbine, in common with all our large turbines, uses a solid forged steel rotor with the rotating blades carried in grooves machined in the rotor forging. The rotor forging material used depends on design and operating conditions. Plain carbon steel was first employed and has an excellent operating record. Advances in operating temperature and blade load have required the development of alloy steels.[6] Nickel steel forgings have long been used where high strength is required, but for the high temperature operating conditions of recent years, the nickel-chromium-molybdenum steels have been developed. These rotor materials must not only have the necessary physical characteristics, they must also possess the stability to operate smoothly for many years. Therefore, it is necessary that heat treatment to give desired properties be coordinated with the heat treatment to give the desired stability. The alloy steels, although offering high physical properties, are more difficult to handle from the stability standpoint. The development of a satisfactory test for judging the suitability of turbine rotors from the standpoint of stability has overcome this difficulty.

### TURBINE CYLINDER CASTINGS

The turbine cylinder is a steel casting in the front or high pressure end, with the exhaust or low pressure end being cast iron. Carbon steel castings are used for the lower operating conditions, with carbon-molybdenum steel castings being used for the more severe steam conditions. Improvement in testing technique, advances in design, and modern methods of examination insure sound alloy steel castings of complicated shapes for the highest pressures and temperatures in use today.[7] In

## TABLE II — Turbine-Generator Units 10,000 kw and larger Purchased by Steel Companies During Past 5 Years

| Size in kw | | 10,000 | 20,000 | 25,000 | 50,000 | Total number | Total kw |
|---|---|---|---|---|---|---|---|
| Number of each size | | 2 | 3 | 3 | 1 | 9 | |
| Total kw in each size | | 20,000 | 60,000 | 75,000 | 50,000 | | 205,000 |
| Pressure, psi gauge | 450 and larger | .. | 3 | 1 | 1 | 5 | 135,000 |
| | 451—650 | .. | .. | 2 | .. | 2 | 50,000 |
| | 651—850 | 2 | .. | .. | .. | 2 | 20,000 |
| Total temperature, F | 750 and lower | 1 | 3 | 3 | 1 | 8 | 195,000 |
| | 751—825 | 1 | .. | .. | .. | 1 | 10,000 |
| | 826—900 | .. | .. | .. | .. | 0 | 0 |
| Speed, rpm | 1500 | .. | 2 | 1 | .. | 3 | 65,000 |
| | 1800 | .. | 1 | .. | 1 | 2 | 70,000 |
| | 3600 | 2 | .. | 2 | .. | 4 | 70,000 |
| Generator coolant | Hydrogen | .. | .. | .. | .. | 0 | 0 |
| | Air | 2 | 3 | 3 | 1 | 9 | 205,000 |
| Turbine type | Condensing | .. | 3 | 3 | 1 | 7 | 185,000 |
| | Non-condensing | 2 | .. | .. | .. | 2 | 20,000 |

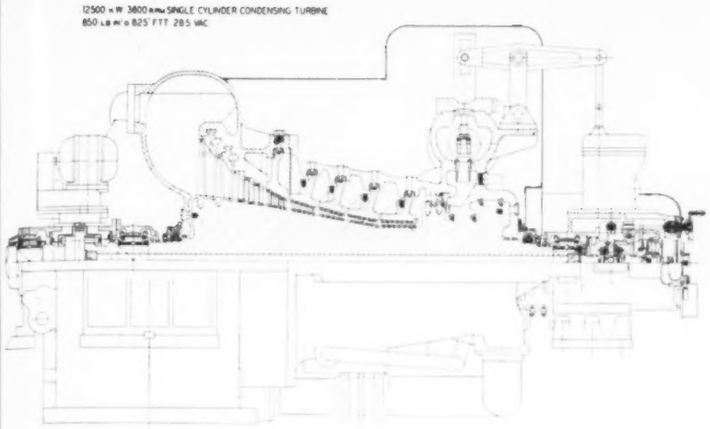


**Figure 2 — Longitudinal section of 12,500 kw, 3600 rpm single cylinder condensing turbine for 850 lb gauge and 825 F total temperature.**

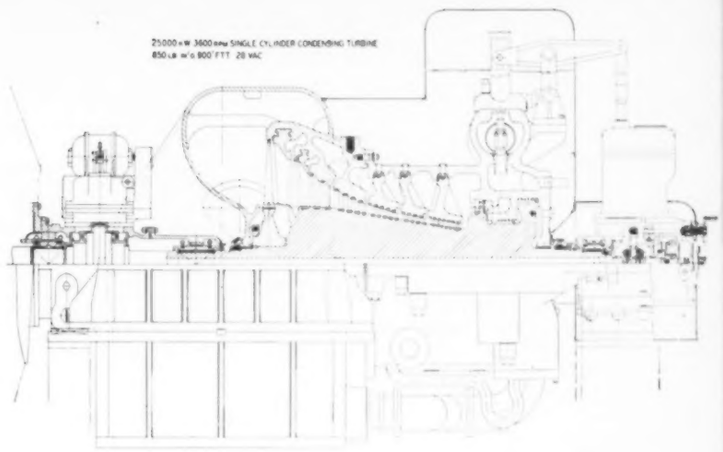


**Figure 4 — Longitudinal section of 25,000 kw, 3600 rpm, single cylinder condensing turbine for 850 lb gauge and 900 F total temperature.**

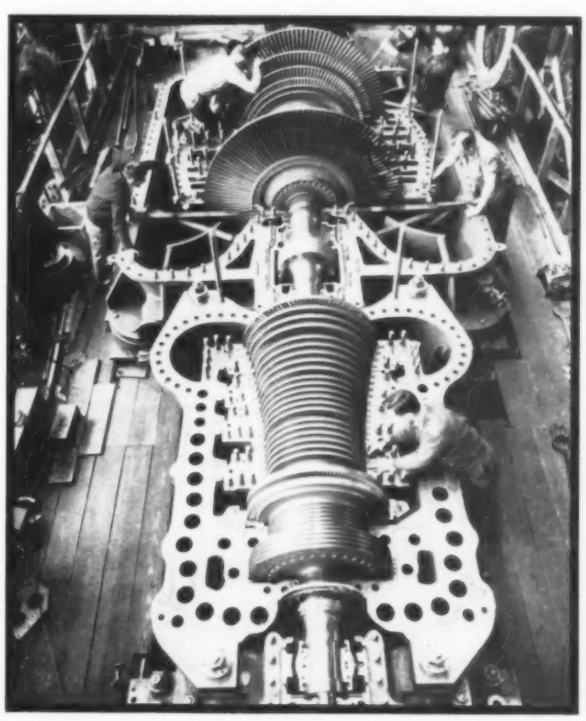
Figure 2 the multi-valve steam chest is an integral part of the turbine cylinder casting. Although this practice complicates the turbine cylinder castings, it has not affected reliability. With the governing valves operating in a steam chest which is an integral part of the turbine cylinder, cored passages in the casting replace external steam connections. This results in a simplification of the overall design, a saving in space, and a considerable reduction in steam trapped between the governing valves and turbine proper.

The stationary blades in the high pressure section are fastened to separate blade rings, which are supported and centered with respect to the rotating element, by the turbine cylinder. The method of mounting is such that the cylinder and the blade rings are free to expand with respect to each other; this minimizes radial differential expansion during transient conditions in turbine operation. Separate blade ring construction[8] is illustrated in Figure 2; and it is also illustrated in Figure 3, which is a view of a tandem turbine with the cover removed. Figure 3 also illustrates modern turbine horizontal cylinder joint design. The separate blade ring construction aids considerably in obtaining a reliable joint design by permitting the use of smooth contour flanges and cylinder walls of uniform thickness. This construction also offers reasonable selection and choice of extraction pressures for feed water heating.

## SINGLE CYLINDER CONDENSING 3600 RPM TURBINES

The turbine design principles just described apply to all our large turbines. Figure 4 is a longitudinal section through a 3600 rpm, 25,000 kw, single cylinder condensing turbine for initial steam conditions of 850 lb gauge and 900 F total temperature. Comparing Figures 2 and 4, it is evident that the turbines are practically identical except for size, the 25,000 kw unit being considerably larger. The 25,000 kw single cylinder condensing turbine represents the largest capacity for which the single cylinder, 3600 rpm, condensing turbine is built. The last row exhaust annulus area determines the leaving loss and therefore the maximum capacity for which a single flow condensing turbine can economically be used. This can be more generally stated: The true capacity of a turbine to expand to a given back pressure, with some arbitrary leaving loss, is measured by the area of the last row annulus and by the sufficiency of the blade design.[1] Therefore the maximum size of the last row annulus limits the capacity

**Figure 3 — View looking into tandem turbine with cover removed.**



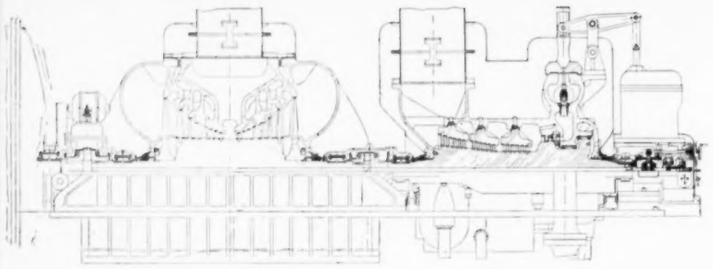


**Figure 5 — Longitudinal section of 60,000 kw, 3600 rpm tandem condensing turbine for 850 lb gauge and 900 F total temperature.**

of the turbine by controlling the leaving loss. This maximum capacity limitation of the single cylinder, 3600 rpm, unit is an economic rather than a physical limitation of the turbine. The last row of blades on the 25,000 kw unit represents the ultimate to date in low pressure blade design. They operate with a tip speed of 1257 fps, over 850 miles per hour. The last row of blades in this unit is carried on a separate disc from the main forging. By this means the optimum physical properties of the disc forging can be obtained. This construction also greatly simplifies machining of the grooves for the side entry buttress roots used to carry these last row low pressure blades. The disc being in the exhaust or low temperature section, there is no danger of its coming loose under the effect of centrifugal force and differential heating; such as would be the case in the high temperature section of the machine.

## TANDEM 3600 RPM TURBINES

The two cylinder tandem, single shaft turbine overcomes the capacity limitations of the single cylinder turbine by utilizing the principal of divided flow. Two low pressure ends are placed back to back and form the low pressure turbine. Steam is fed to the center and divides, half the steam flowing through each end to the condenser. In this way approximately twice the single cylinder capacity can be economically justified. Figure 5 shows a longitudinal section through a 3600 rpm, 60,000 kw tandem turbine for steam conditions of 850 lb gauge and 900 F total temperature. Comparing the tandem and single cylinder sections, it is apparent that the two types of machines have considerable in common from a design standpoint. They consist of two basic elements, a high pressure element and a low pressure element. The single cylinder condensing turbine uses a high and a low pressure element in a single cylinder, and the tandem turbine uses a high pressure element in one cylinder solidly coupled to two low pressure elements placed back to back in a separate low pressure cylinder.

This building up of turbines from relatively standard elements has many advantages. Although the requirements of industry are such that individual units, especially of the larger size, are usually tailor made, the use of standard elements in making up these machines goes a long way in holding down the cost of individual machines. A second advantage is that operating experience is rapidly acquired; it is very much like model testing. For example, if a single cylinder turbine has had adequate field experience, a tandem turbine for at least twice the capacity can be built with every confidence that it will operate with equal reliability to that of the single cylinder machine. It operates with very nearly the same elements except for number and arrangement.

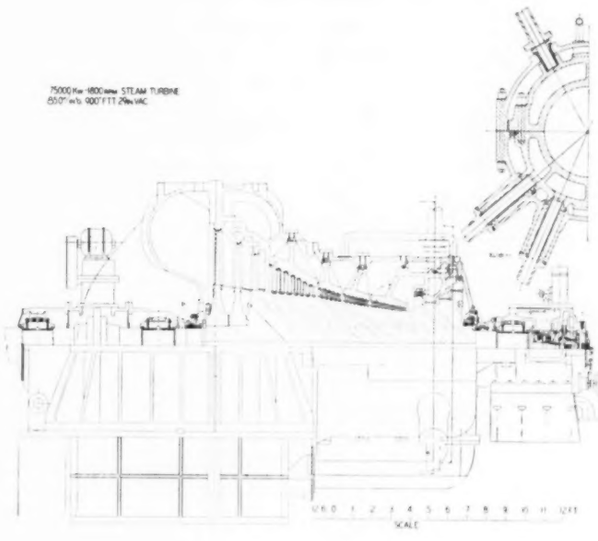


**Figure 6 — (left) Longitudinal section of 60,000 kw, 1800 rpm single cylinder condensing turbine for 450 lb gauge and 750 F total temperature.**

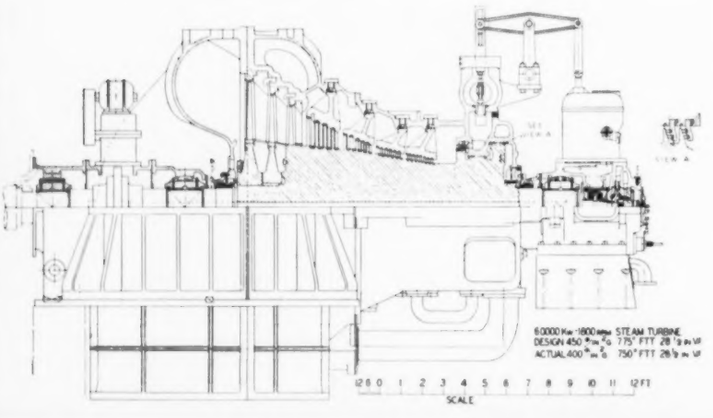


**Figure 7 — (above) Longitudinal section of 75,000 kw, 1800 rpm single cylinder condensing turbine proposed for high initial steam conditions.**

## SINGLE CYLINDER AND TANDEM 1800 RPM TURBINES

For all ratings up to and including 60,000 kw the 3600 rpm machine is the turbine which is normally used in modern practice. For ratings in excess of 60,000 kw, the 1800 rpm machine is normally used. It was stated earlier that for geometrically similar turbines halving the speed gave 4 times the capacity. Therefore, 1800 rpm turbines geometrically similar to 3600 rpm turbines should have maximum capacities approximately as follows:

Single cylinder 1800 rpm . . . . . 100,000 kw
Tandem (single shaft) 1800 rpm . . . . . 200,000 kw

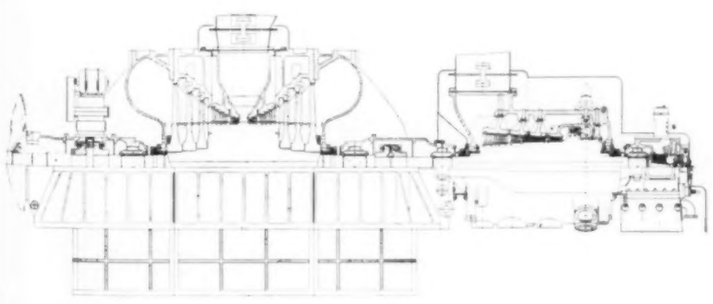
A 165,000 kw tandem condensing turbine is the largest 1800 rpm single shaft tandem turbine built to date.

In Figure 6 a longitudinal section through an 1800 rpm, 60,000 kw single cylinder condensing turbine for steam conditions of 450 lb and 750 F total temperature is shown. Figure 7 shows what the 1800 rpm single cylinder turbine designed for high initial steam conditions will look like. Figure 8 is a longitudinal section through a 150,000 kw, 1800 rpm, tandem turbine for 1250 lb gauge pressure and 925 F total temperature. A comparison of these longitudinal sections with those for the 3600 rpm turbines shows that the greatest difference between these turbines for different speeds of rotation is one of size. It was pointed out earlier that the large size of the 1800 rpm machine meant relatively heavy cylinder wall castings and that this was one of the reasons for the development of the 3600 rpm machine. The design of the high pressure single cylinder turbine, and of the high pressure section of the 150,000 kw tandem turbine shows the method used to get around the problem of heavy cylinder wall and flange bolting construction for 1800 rpm machines when operating at high pressure and temperature. This is accomplished by what is known as a double wall construction. The high pressure portion of the turbine cylinder consists of two casings, one placed within the other. The high pressure and high temperature steam is admitted to the inner casing through pipes which pass through the outer casing. The steam is partially expanded in the inner casing and this reduced pressure and temperature steam fills the space between the inner and outer casing. The steam space, then, between the two casings is subjected to a pressure which varies with the flow through the machine but which is materially lower than the throttle or inlet steam pressure and temperature. The walls of the inner casing, instead of being subjected to and designed for full pressure and temperature differential, namely, 1250 lb gauge and 925 F down to atmospheric conditions, will be subjected to a differential from 1250 lb and 925 F to some intermediate pressure and temperature. Likewise,the outer casing need only be designed for a differential from the intermediate pressure and temperature to atmospheric conditions. The net effect is a turbine with thinner cylinder walls and smaller flanges and bolts. These factors, combined with the fact that the inner casing is kept at a relatively constant high temperature, keeps distortion to a minimum.

## SUPERPOSED TURBINES

A type of turbine which has become popular within recent years is the superposed turbine.[9] It is a high pressure and temperature non-condensing turbine, the exhaust of which becomes the steam supply for existing low pressure turbines. This type of turbine became popular with the development of designs capable of operating with initial steam temperatures of 950 F at pressure of the order of 1250 lb gauge. Operation with this initial high pressure and temperature makes it unnecessary to reheat the steam at an intermediate pressure, in its expansion down to condenser vacuum, to prevent excessive moisture in the exhaust. With the complication of reheat unnecessary, due to high initial temperature, the superposed turbine became popular as the method of making available to existing low pressure plants the advantages of high pressure and temperature while protecting investment in existing low pressure equipment.[10]

A 50,000 kw superposed turbine for steam conditions of 1600 lb and 950 F is shown in Figure 9. It is apparent



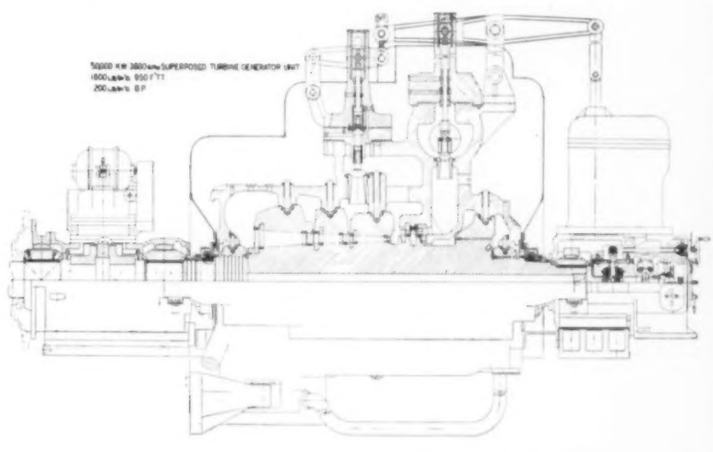


**Figure 8 — (left) Longitudinal section of 150,000 kw, 1800 rpm tandem condensing turbine for 1250 lb gauge and 925 F total temperature.**

**Figure 9 — (above) Longitudinal section of 50,000 kw superposed turbine for steam conditions of 1600 lb gauge, 950 F total temperature and 200 lb exhaust pressure.**

that the high pressure superposed turbine is not so far different in design from the high pressure turbine of a 3600 rpm tandem condensing unit. The solid rotor construction for the high initial steam condition has played no small part in the excellent operating record being compiled by machines such as this.

Reaction blading on these modern superposed turbines is arranged on a constant effective mean diameter. With this arrangement, the balance piston can be proportioned to give an equilibrium condition regardless of stage pressure distribution as a result of carry-over in the steam depositing on the turbine blades.

The section of the superposed turbine illustrates clearly the so-called internal bypass. This is an older construction which has been revived because of its many advantages when used with high pressure and temperature steam conditions. The first stage is normally a two-row impulse stage (Curtis stage) which is used to obtain a relatively flat efficiency curve over a wide load range. This two-row impulse stage takes a large drop in pressure and temperature at all loads and therefore limits the pressure and temperature to which the turbine cylinder proper and the rotor are exposed. The internal bypass is provided by a separate valve under control of the governor. This valve bypasses steam around a section of blading, intermediate in the blade path, to limit the maximum steam pressure and temperature in the turbine cylinder when handling steam flows near the maximum output. At no time is the turbine cylinder and rotor exposed to initial steam pressure and temperature at a point beyond the nozzles to the first stage impulse wheel, as all the steam must first pass through the impulse wheel. The internal bypass has additional advantages in that it permits the impulse element to operate at near peak efficiency over a wide range of load, and it reduces the mechanical duty of impulse blades.

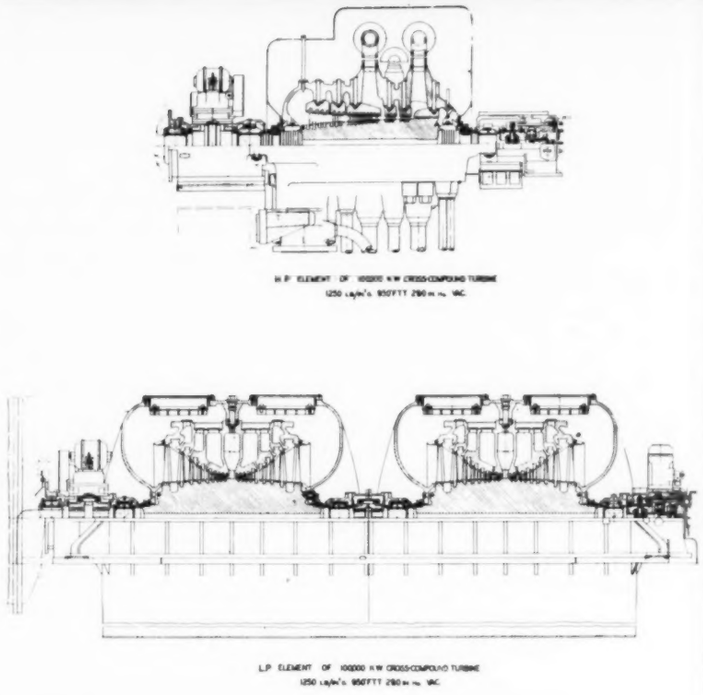
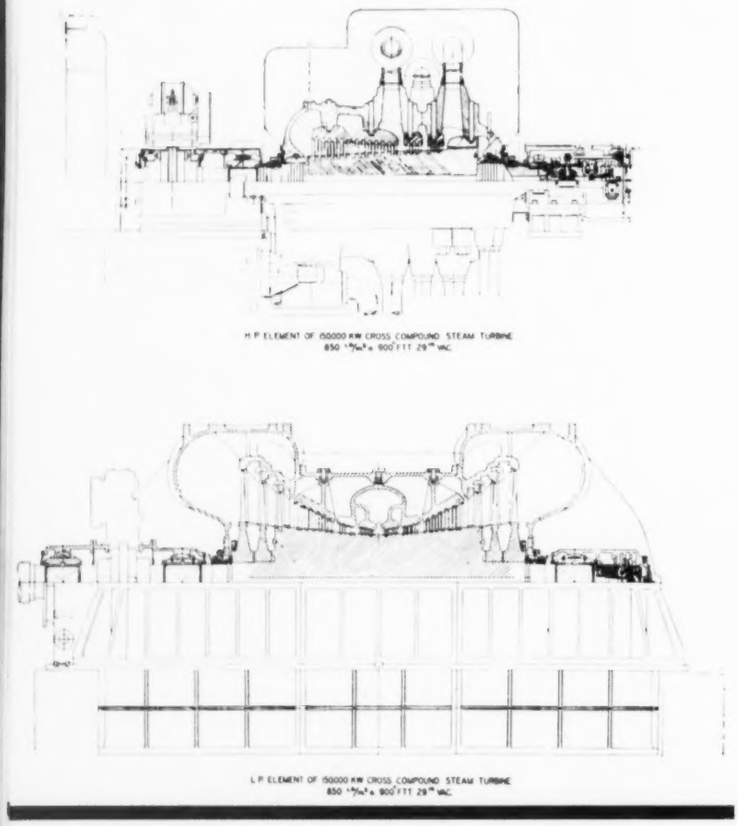


**Figure 10 — Longitudinal section of 100,000 kw, 3600 rpm, cross-compound condensing turbine for 1250 lb gauge and 950 F total temperature.**

**Figure 11 — Longitudinal section of 150,000 kw, cross-compound, 3600 rpm high pressure and 1800 rpm low pressure turbine for 850 lb gauge and 900 F.**



## SPECIAL LARGE TURBINE GENERATOR UNITS

To meet special operating conditions and system requirements many turbine generator units vary considerably from the types described. A 100,000 kw turbine (125,000 kw maximum capacity) for operation at 3600 rpm is shown in Figure 10. This turbine is designed for initial steam conditions of 1250 lb gauge at 950 F total temperature. A 50,000 kw high pressure turbine drives one generator and exhausts into a 50,000 kw low pressure turbine, consisting of two double flow, low pressure elements coupled together and driving a second generator. To obtain 125,000 kw maximum capacity at 3600 rpm, cross-compounding is necessary. (Using the accepted tandem turbine the maximum capacity for which a double flow low pressure end has been built is 65,000 kw. The maximum capacity for which the 3600 rpm generator has been built is 65,000 kw at 0.8 power factor, but generator engineers are prepared to build generators for 75,000 kw at 0.8 power factor.) By using two double flow low-pressure elements the last row exhaust annulus area of four 25,000 kw turbines shown in Figure 4 is obtained. The two low pressure turbines are joined in the base to

provide a single exhaust opening, to which the condenser will be welded. The low pressure cylinder base is fabricated of steel castings and structural members to provide suitable strength and rigidity required by the necessarily great longitudinal span.

Figure 11 shows a 150,000 kw cross-compound turbine designed for initial steam condition of 850 lb and 900 F total temperature. This unit consists of a 3600 rpm high pressure turbine and an 1800 rpm low pressure turbine. The turbine has a maximum rating of 187,500 kw. Due to limitations in size of 3600 rpm generators, it was necessary to divide the capacity non-uniformly between the 3600 rpm high and the 1800 rpm low pressure turbines. Units such as this carry the advantages of the physically smaller 3600 rpm turbines for high initial pressure and temperature into the larger ratings. This advantage in the minds of many operators more than offsets any of the disadvantages of cross-compounding.

The largest 3600 rpm generator built to date is rated 81,250 kw at unity factor when operating with hydrogen, at ½ lb pressure, as the cooling medium. This generator is driven by a superposed turbine operating at initial steam conditions of 1250 lb gauge, 925 F total temperature and exhausting at 200 lb. A longitudinal section of this turbine is shown in Figure 12. The small turbine coupled to the superposed turbine is a feed heating turbine arranged for extraction for feed water heating. By an arrangement such as this the older low pressure turbines are not only superposed but the advantages of regenerative feed water heating are also obtained. This unit is one of four superposition turbine-generator units, installed in the same station with a total capacity of 230,000 kw. This is the largest superposition capacity ever placed on one system.

## TURBINE CONTROL

A problem which is receiving much attention and study is one of turbine control. In steel mills the large and rapid swings in rolling mill load with or without purchased power interconnection, and the partial use of waste heat boilers makes the control problem an important part of the application. Developments made in the turbine control system have resulted in governors of greater sensitivity, speed of response and adaptability to various controls, than those used on older machines. Governor requirements and necessary specifications have never been generally agreed on. At the present time, joint committees of the A. S. M. E. and A. I. E. E. are working toward the preparation of steam turbine control system standards and specifications.

All of our modern large turbines use a transformer type oil governor.[11] In this oil governor an oil pressure which varies as a function of speed is amplified and used to control the turbine instead of the older spring-loaded flyball type of speed responsive element. The governor and control system is shown schematically in Figure 13. The complete governor unit, including transformer (hydraulic pressure amplifying device), relays, speed changer, and servo-motor (power piston) is built into a compact unit. In this unit oil passages replace the usual mechanical linkage, for the governing function is performed by relays under control of oil pressure. This gives an extremely simple, fast, and fundamentally reliable governing system.

An outstanding feature of this modern governor is its adaptability to special control mechanisms. A number of these have been developed for special application in connection with steel mill power plant turbines. An article appearing in *Iron and Steel Engineer*, November, 1940, gave an interesting application. It consisted of a load anticipator which caused certain of the steel mill power plant turbines to absorb the rapid changes in load incidental to steel mill demands. Normally, with no special control devices being used, change in plant load is divided between tie line and plant in the ratio of their connected running capacity.

In any system in which load is changed very rapidly, the problem normally becomes one of the boiler's ability to respond rather than one of turbine limitation.

**Figure 12 — (below) Longitudinal section of 65,000 kw, 3600 rpm, superposed turbine for 1250 lb gauge, 925 F total temperature and 200 lb exhaust pressure.**

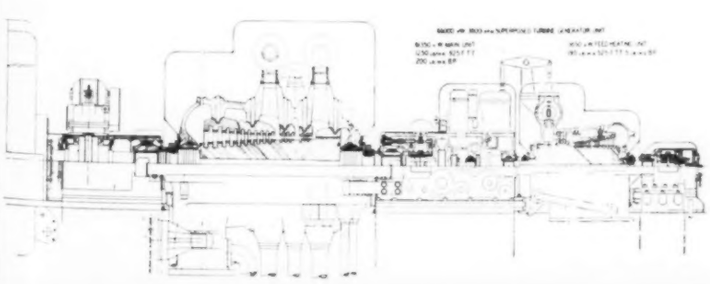
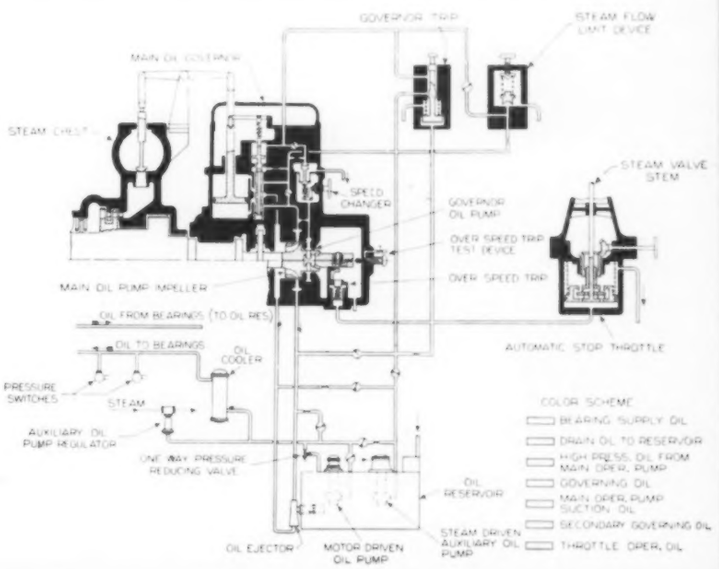


**Figure 13 — (right) Oil system and control diagram of modern turbine with oil governor.**



To solve this problem, one utility with rapid load swings from connected steel mill load, has added isochronous control to certain units on their system. The isochronous control gives the unit very low speed regulation with respect to the other units on the system, and for very small change in system frequency this unit either picks up or drops practically all the load change. This keeps the rapidly changing load from affecting system frequency appreciably. However, the boiler feeding the isochronous unit has to meet the rapidly changing steam demand. To prevent the turbine from calling for steam quantities beyond the boiler's ability to respond satisfactorily, the isochronous control is used in conjunction with a steam flow limit control. This device limits the governing valve opening and therefore the maximum amount of steam the governor can call for.

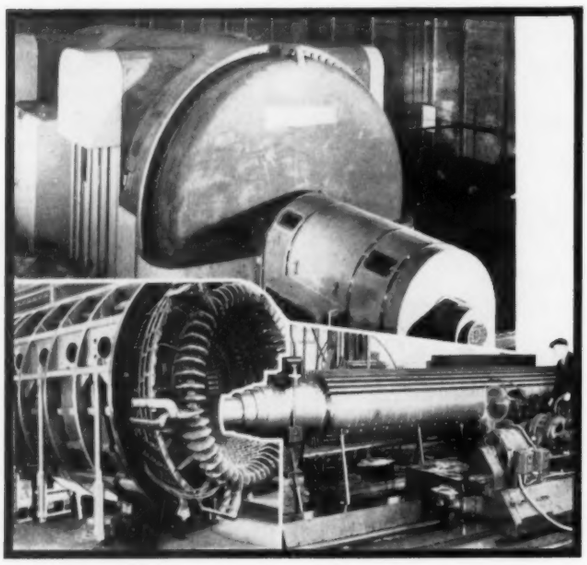


**Figure 14 — Hydrogen cooled generator, 65,000 kw, 3600 rpm, illustrating generator stator supports and cross-slotting of generator rotor.**

### 3600 RPM GENERATORS

Very closely related to the development of the 3600 rpm turbine has been the development of 3600 rpm generators. Outstanding developments in this field are: hydrogen cooling,[13] and a very successful method of mounting the stator core,[14,15] to isolate from related structures an inherent 120 cycle stator vibration.

In the first 3600 rpm generators for capacities of 25,000 kw and larger a 120 cycle vibration caused considerable concern. This vibration, at twice the running speed, was small in amplitude but noisy and caused disturbing vibration in remote sections of the power plant. The vibration was caused by the powerful, rotating, two pole magnetic field distorting the generator stator, and by the non-uniform moment of inertia of the generator rotor caused by the slots for the field windings.

Figure 14 shows a composite picture of a 65,000 kw hydrogen cooled, 3600 rpm generator, generator stator and generator rotor. The method of design to avoid the (double frequency) 120 cycle vibration is illustrated. Cross slotting the rotor as indicated gave it the same moment of inertia in all planes. The vibration caused by the powerful magnetic field was overcome by isolating the stator core from the foundation by a flexible mounting. The success of this design is demonstrated by the fact that it is practically impossible to tell when the field is turned on or off of one of these modern 3600 rpm generators.

### CONCLUSION

During the past ten years the rate of development and change in accepted turbine practice, especially in the 3600 rpm turbine-generator unit, has been at an accelerated rate. At the present time the types of turbines and their accepted application has been fairly well standardized. In this paper I have outlined modern turbine practice and modern turbine types as my company builds them. Modern turbine design problems and methods of solving these problems are not dealt with in any detail, as these factors have been covered in several recent articles dealing exclusively with this subject.[2,7,8,12] In describing each of the different types of units some of the more important design features are pointed out and briefly described.

These modern units for high initial steam conditions, have proven themselves under the test of practical operation. Their performance and reliability has been amply demonstrated. The steel companies are accepting these units and I believe it is safe to predict that the types of units described are the turbines that will be purchased by the steel companies in the future.

### REFERENCES


1. *Steam Turbines* by FRANCIS HODGKINSON, Journal of Franklin Institute Vol. 219, No. 5, May, and No. 6, June, 1935.
2. *Turbine Developments and Their Application to the Steel Industry* by C. B. CAMPBELL, Iron & Steel Engineer, September, 1937.
3. *Calculation of the Gain from Feed Water Heating* by R. L. REYNOLDS, The Electric Journal, April, May and June, 1929.
4. *Progress in Design and Performance of Modern Large Steam Turbines for Generator Drive* by G. B. WARREN, Transaction of the A. S. M. E., January, 1941.
5. *What Will 1943 Turbines be Like?*, by F. K. FISCHER and J. R. CARLSON, Power, March, 1942.
6. *Turbine Rotor Forgings and Their Heat Treatment* by N. L. MOCHEL, Metals and Alloys, October, 1937.
7. *Trends in Steel Mill Power Generation* by C. C. FRANCK, Iron & Steel Engineer, November, 1940, Pages 18-23.
8. *Modern Steam Turbine Design* by C. C. FRANCK, Proceedings of the Midwest Power Conference, Vol. IV, 1941, Pages 39-52.
9. *Superposed Steam Turbines* by F. K. FISCHER, Drexel Technical Journal, January, 1942.
10. *Modernization of Steam Plants with High Pressure Turbine Exhausting into Existing Low Pressure Units* by E. ZETTERQUIST and N. D. GOVE, The Electric Journal, February and April, 1935.
11. *Constant System Speed and the Steam Turbine Governor* by A. F. SCHWENDNER, Transaction of the A. S. M. E., April, 1940.
12. *Modern Turbine Developments* by J. R. CARLSON, Combustion, March, 1942.
13. *Hydrogen Cooling of Rotating Machines* by C. M. LAFOON, Trans. A. I. E. E., Vol. 55, 1936.
14. *Special Problems of Two Pole Turbine Generator* by C. M. LAFFOON and B. A. ROSE, A. I. E. E., North Eastern District Meeting, May, 1939.
15. *Vibration of Frame Reduced on Waterside Generator* by T. R. GALLOWAY and B. A. ROSE, Electrical World, December, 1940.

# DISCUSSION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E. E. THOMAS: I would like to congratulate Mr. Fischer on his able presentation of an excellent paper for the steam turbine-generator industry. I was interested in its historical features which made me think back over the years of growth in the development of this industry. The bibliography includes reference to a paper presented by G. B. Warren two years ago as a contribution by the Power Division of the American Society of Mechanical Engineers. This paper is an excellent companion paper to the one Mr. Fischer has just presented.

Mr. Fischer portrays the development of the steam turbine art thoroughly and gives considerable information on hydrogen cooling of the generator. Perhaps I can add something to the latter subject.

The bibliography by Mr. Warren includes a reference back to the year of 1925 for a paper given before the American Institute of Electrical Engineers about "Hydrogen as a Cooling Medium for Electrical Machines." I am personally interested in this because it was my duty to obtain heat transfer test information used in that paper to show relative performance when using air or hydrogen for the cooling medium.

Much of my work since then has been and is closely associated with the application of turbines and generators to industrial uses. My prior experiences as turbine foreman brought me into intimate contact with operating conditions. I make these remarks to show my appreciation of design conditions and operation of such equipment.

Mr. Fischer has pointed out that, from the standpoint of overall economics, we should not go much below 20,000 kw in size of machine to apply hydrogen at this time. However, it should be noted that the percentage of saving in active material by hydrogen cooling is, of course, practically the same for much smaller electrical revolving machines. Such a saving is in the order of about 25 per cent when using hydrogen at a pressure slightly above atmospheric. If the same temperature rise conditions are maintained and the hydrogen pressure is increased to 15 pounds gauge an additional 15 per cent increase in output may be realized as pointed out by Mr. Fischer.

Although the first installation of a steam turbine generator unit equipped with hydrogen cooling features was made during the year of 1937, the application of the hydrogen cooling method was made on large synchronous condensers during the year of 1928. Hydrogen cooling equipment has been made a part of approximately 3,000,000 kw in steam turbine-generator capacity during the last five years. At least one hydrogen cooled unit is being built for the steel mill industry which further indicates that the hydrogen cooling procedure is a good and conservative one. The rapid increase in the use of hydrogen cooling of generators is due to advantages as follows:

1. Due to the lower density of hydrogen, windage losses are about 10 per cent of those for an air cooled generator.

2. As a result of the superior cooling properties of hydrogen, greater output can be obtained with the same active material. Hydrogen has a thermal conductivity 7 times that of air.

3. The effect of corona on insulation is negligible in hydrogen and the insulation retains its flexibility longer.

4. As hydrogen will not support combustion, fire hazard is minimized.

5. Since the windage losses may represent 40 to 50 per cent of the full load losses in an air cooled generator, the use of hydrogen results in an appreciable gain in efficiency.

6. The size of the gas coolers of the hydrogen cooled generator is smaller than that of air cooled generators. Losses to be removed are less and the rate of heat transfer to the cooler tubes is greater.

7. The casing must be gas-tight and dirt and moisture effectively excluded, resulting in a cleaner generator with reduced maintenance.

Today, you might say hydrogen cooling of large generators represents a way to get 25 per cent more power out of its Critical List Materials or possibly 40 per cent more power may be realized if the hydrogen is used at 15 lb gauge pressure. Such savings are especially desirable at this time owing to war emergency conditions.

W. B. TUCKER: I want to compliment the author on the method in which he has presented his paper as well as the material his paper contains. The method in which the physical relationships between low speed turbines and high speed turbines has been expressed is very interesting and is especially useful for quick comparisons.

Mr. Fischer points out the features of the construction used by his company to take care of expansion and contraction of those parts that pass through the greatest temperature changes during starting, stopping and operation period of a turbine. The double cylinder construction shown by the author in the high pressure portion of one of the turbine sections attacks the problem of cylinder joint leakage by reducing the pressure and temperature difference between the outside and

inside cylinder walls. The writer's company in the past has met this problem of holding tight cylinder joints in large diameter cylinders, where internal pressures are high, by using the Dahlstrand cylinder clamps. These clamps are of special design which allow the use of two rows of flange bolts and thus reduce the bolt stress, necessary to produce the required joint pressures, by more than 33 per cent. It is interesting to see that others are attacking this problem from another angle.

We are now building a 147,000 kilowatt, 1250 pound, 925 degree, 1800 rpm, condensing turbine-generator unit which has a double flow low pressure spindle construction that should be of interest to engineers in the steel industry.

The largest diameter of this spindle is 76 inches and its finished weight will be approximately 100,000 pounds. The conventional method of building a low pressure rotating element of this size is to shrink on a number of discs (76 in. diameter) on to a shaft of approximately 30 inches in diameter. Each disc will have one or more rows of blades mounted on its circumference. If we would weld the periphery of each of these adjoining discs together and have each end disc integral with stub ends to form the bearing journals, we could omit that portion of the spindle shaft that passes through the large holes in the discs. By elimination of these large holes in the discs we avoid the high tangential stresses in the disc metal at the holes. This is exactly what we are doing. This construction also eliminates considerable weight in the rotating element resulting in material saving, reduces load on the bearings of the low pressure element and eliminates shrunk-on rotating parts which, at times, have proven troublesome.

The process of making the forged discs and stub-ends is not unusual but the method of welding these discs together at their circumference should be of interest.

The discs are temporarily held in welding position by several bars which are welded across the rims of the discs at intervals. Now, the job is placed in a special insulated rotating machine where it is held at a uniform temperature of 500 F by eighteen 1000 watt infra-red lamps and is rotated at a rate of two revolutions per hour.

A ¼ in. carbon-molybdenum welding rod is used to lay a weave against the chill ring and the bottom of the 3 in. groove between the discs. The maximum width of weave permitted is one inch. As the groove is filled, more than one weave is necessary to cover the full width of the groove until three overlapping weaves are laid across the top of the groove at the outer circumference.

During the continuous process of welding the weave is constantly cleaned and peened to work the weld and avoid distortion of the rings. All welds are inspected by a gamma ray capsule placed at the axis of the spindle after each weld is completed.

To my knowledge, this is the first spindle to be built in this country by the method described and the first one of such size to be built anywhere.

**HAROLD STOTT:** I was quite happy to note in reading the paper and perusing the references a wholesome getting together of the manufacturers of this major equipment. Mr. Fischer stated that the 900 lb, 3600 rpm machines have been run long enough now in our utility central stations to completely justify their installation in our steel industry. In this connection we must be prepared to make the necessary improvements in our boiler feed water and general operating conditions. We can get by with conditions in the 250 psi, 500 F plant that will not go in the 900 psi 850 F plant; of course the improvements are now time-tried and available. Mr. Fischer brought out very admirably the building up of our larger turbo-generators from field-tested medium sized machines, making it possible today to build a machine of any commercial capacity and be reasonably sure to meet the guarantees.

**R. D. MCARTHUR:** The only thing that occurred to me — and this is an operating problem purely and simply, and not a matter of design — is that as we go to the higher pressures, and especially temperatures in the larger machines, the exhaust temperatures at the very light loads become an item that can't be forgotten. For instance, if you take a 1200 lb, 900 F condensing machine, under some conditions at zero load you can get temperatures up to 600 F or 700 F in the exhaust. This means that the operators must make provision for leaving the machines on the line at no load a much shorter time than is possible when you are running with the low pressures and temperatures, because if you are running very long, the exhaust temperatures get to a point where you are going to have deterioration or rubbing, or both.

**A. J. FISHER:** I would like to ask Mr. Fischer if he would comment historically on the pounds of coal per kilowatt produced by the electrical industry in the United States for, say, the past ten or fifteen years.

**F. K. FISCHER:** In commenting on the pounds of coal per kwhr, if we go back to about 1900 we can find stations of 5 per cent cycle efficiency which means about 6 lb of coal per kwhr. In this connection, it should be realized that the heat rate shown in Figure 1 is turbine heat rate and not plant heat rate. To change this to plant heat rate, it is necessary to correct it for the boiler efficiency and the power used by auxiliaries. This turbine heat rate shown in Figure 1 represents best unit performance for the period. The 23,000 Btu per kwhr turbine heat rate shown for 1900, when corrected for boiler efficiency and power used by auxiliaries, represents approximately 3 lb of coal per kwhr as best plant performance in 1900. According to statistics for all plants having an output of 10,000 kwhr per month, the average for the industry was approximately 3.5 lb of coal per kwhr in 1920 with a best plant rate of approximately 1.5 lb per kwhr. The 1931 average for the industry is given as 1.55 lb per kwhr with a best plant rate of approximately 0.9 lb per kwhr. In 1940, the average for the industry is given as 1.36 lb per kwhr while the best plant is approximately .8 lb of coal per kwhr.

**J. H. STRASSBURGER:** I was very interested in Mr. Fischer's paper and he covered the subject of turbine generators very thoroughly. At Weirton we are operating two 12,500 kw high pressure machines. These machines have a throttle design of 800 pounds, 825 degrees, and exhaust at 225 pounds, 540 degrees. The machines are about 3600 rpm. One machine has been operating since June, 1936 and the second machine

(*Please turn to page 65*)

# Synthetic Coverings FOR Wire AND Cable

***. . . . among other fields where plastics have demonstrated their performance is the wire and cable industry . . . . superior to rubber in several ways, plastics will find new uses as a result of the present developments . . . .***

*by Guy N. Everest,* RESEARCH ENGINEER

THE OKONITE COMPANY

PASSAIC, NEW JERSEY

▲ ALTHOUGH a decade of research and practical manufacturing experience lies behind the already prevalent use of synthetic rubber-like materials in the wire and cable industry, the war has brought about a condition that is forcing this industry into a more general use of these relatively new materials.

Hitherto the synthetics have been used primarily not as substitutes but because of their own intrinsic merit. The ample supply of low cost rubber made the use of synthetics impractical except for applications where certain of their characteristics such as non-inflammability, resistance to oils, ozone and sunlight, resulted in longer cable life.

Today, however, this situation has been radically changed. Our rubber supply has been cut to a negligible quantity, and most of it has been dedicated to direct war applications. As a result of the drastic government regulations regarding the conservation of this rubber, it has become very necessary for the wire and cable manufacturers actually to substitute synthetics wherever possible and, in other cases, to reduce the rubber content of insulating compounds to the barest minimum.

Fortunately, experience already gained can be put to immediate use.

For example, there are the plasticized vinyl chloride polymers. This type of material, a leather-like thermoplastic, has been used very extensively both as a wire insulation and as a protective cable sheath. When heated, it is easily worked with the regular rubber compounding machinery and can be readily extruded over copper conductors or over an assembled cable core. This plastic is quite familiar to electrical men as it is in general use on the new small diameter building wire known as type SN and approved under the 1940 National Electric Code. It has also been used extensively as insulation for switchboard and instrument wiring. Vast quantities have been used in insulating and sheathing cables made for the U. S. Navy during the past 6 or 7 years. Still other uses for this material have been as a jacket to protect lead sheaths from electrolysis and chemical corrosion. Cables protected with polyvinyl chloride synthetics are characterized by great ability to resist oils, acids and other chemicals. They are non-inflammable and tough. They are entirely satisfactory for installation and use in commercial and industrial applications.

Since the electrical characteristics of this material are fairly good it can readily serve as insulation for low-voltage applications. This is not the case, however, with many of the other synthetics in general use. They are primarily suitable as mechanical protection over other materials used as the insulation.

**Figure 1 — Schematic diagram of proving ground, where many cables are buried in various types of soil and tested at periodic intervals to determine the behavior of insulating materials.**

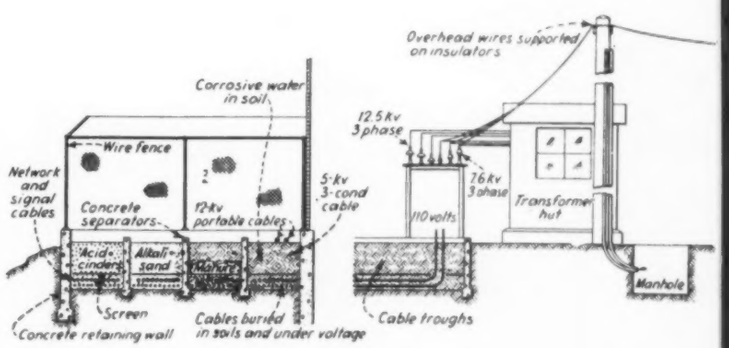
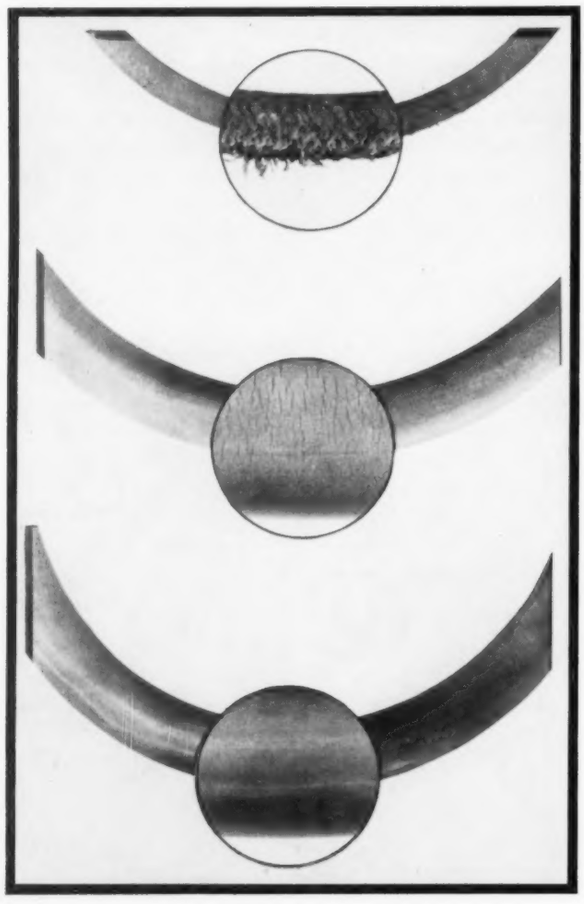


**Figure 2 — (above) The bus structure and the four trenches with buried cable in proving ground. Cables on surface are high voltage electric shovel cables.**

**Figure 3 — (below) Comparison of braided (top), rubber-sheathed (middle), and neoprene-protected braided cables after exposure to the elements for more than 6 years.**



It might be pointed out here that, for general purposes, the most practical solution seems to be a judicious combination of synthetics and rubber since the manufacturing facilities for production of the synthetics are as yet extremely limited and until processing plants now building are in full operation nowhere near enough will be available for the needs of the wire and cable industry, much less for the growing needs of other industries. Furthermore, no substitute yet available has all the desirable qualities of rubber as an insulation for electrical wires and cables, especially for higher voltages.

Fortunately, this situation can be met in a most satisfactory manner with a cable design introduced about five years ago and which has been used successfully in practically every conceivable type of service — overhead, underground in ducts or buried, in vertical and horizontal conduit and for interior construction.

This type of cable is insulated with a well-proved rubber compound which is in turn protected by a neoprene sheath. The insulation contains a relatively small proportion of rubber and fulfills even the more drastic government regulations in regard to the conservation of rubber for high grade insulated wire. This type of insulation is known as oil-base ozone resistant rubber compound and its wide use for a good many years under the most severe conditions has established beyond doubt that it is reliable for service up to 35,000 volts.

One of the major problems that has confronted cable manufacturers is the need for protecting rubber insulation with a non-fibrous covering that would have as long a life as the insulation itself. In non-metallic sheathed cables, the usual coverings have been fibrous braids, jute rovings and rubber jackets.

Fibrous coverings even when saturated have but a limited life as they rot when subjected to alternately wet and dry conditions and eventually expose the rubber insulation below and hasten its deterioration. Rubber jackets have made an excellent name for themselves and have proved their superior characteristics especially for use in conduit both indoors and outdoors as well as for direct burial and, of course, for portable cables. Rubber jackets, however, contain large percentages of rubber in order to gain mechanical strength and moisture resistance but such rich rubber compounds are susceptible to attack by sunlight, ozone, oils, certain chemicals and they are not non-inflammable. Furthermore, conservation makes these rubber jackets out of the question today.

About five years ago neoprene, which had already been used to a limited extent for portable cords, was adopted for more general use on wires and cables. This stable rubber-like polymer, synthesized from coal, limestone and salt, has many characteristics such as non-inflammability, ozone, oil and sunlight-resistance that make it eminently suitable as a cable sheath to supplant both fibrous and rubber coverings as it eliminates their innate weaknesses.

When applied by the strip-insulating process, neoprene sheaths can be applied over the insulation in uniform thicknesses as small as $\frac{1}{64}$-inch. In many cases, this makes possible an actual reduction in the overall diameter of the wires. It also means that the rubber-insulation can be sealed within an air-tight covering that will protect the vital insulation indefinitely. To obtain all

## TABLE I — Characteristics of Neoprene-Protected Cables with Oil-Base Insulation

*Oil base insulation*

Ozone resistance
Moisture resistance
Acid and alkali resistance
High dielectric strength
Low dielectric loss
Suitable for voltages up to 35,000
Low S. I. C.
Stable under wet conditions
Heat resistant
Light in weight and flexible
Easy to splice and terminate
Service proved under all kinds of conditions for over 15 years
Especially suited for non-leaded submarine installation

*Neoprene sheath*

Ozone resistance
Moisture resistance
Acid and alkali resistance
Sun resistance
Oil resistance
Non-inflammable
Heat resistance
Light and flexible
Easy to splice and terminate
Eliminates saturating compounds and fibrous coverings overall
Tough and easy to handle
Available in colors for identification purposes
A permanent covering
Suitable for direct burial in ground, in ducts or aerially
Service proven for over 8 years

these characteristics experience dictates that the sheath compound should contain at least 50 per cent of neoprene by weight. Cables of this design — single conductor with an oil-base insulation and a bonded neoprene sheath — are of the simplest possible construction and can be spliced and handled even more easily and satisfactorily than conventional braided wire.

One particular application in which neoprene has solved some problems is in the 4150 and 2300 volt class of riser cables where trouble from deterioration of rubber jackets or fibrous braids occurred from ozone attack. The conventional method was to use braided or rubber jacketed cable from a pole line down the pole in fibre and metal conduit to the underground duct system, which might involve 100 feet or longer runs. When the cables had been in service a short while failures had occurred and it was found that braids were weak, rotted, charred and in many cases completely destroyed. Rubber jacketed cables also failed and it was found the rubber jacket was cracked and the surface contained many small "cuts" which were similar to the condition that results from exposure to sun or ozone. After a long investigation of the causes of these failures it was finally found that in order to operate under the service conditions the *completed* cable must be ozone resistant, have high surface resistance and not show discharge or generate ozone at voltages below 3500 to ground. The neoprene-protected cable possesses these characteristics.

This cable also has solved trolley-coach wiring problems for not only does the neoprene sheath prevent static charges being transferred to the coach body but its non-inflammability reduces the fire hazard. In addition this cable is oil resistant and has good flexibility at low temperatures.

Neoprene-sheathed cables with oil-base insulation can be used in their simplest form for services up to 5000 volts, and similar designs with static shielding interposed between the insulation and the sheath can be used in single or multiple conductor form up to 35,000 volts.

The applications of this cable design are practically

**Figure 4 — (below) The effect of oil on rubber insulated cable, braided cable and neoprene-sheathed cable. The last has hardly been affected while the oil has swelled or burst the other type cables.**

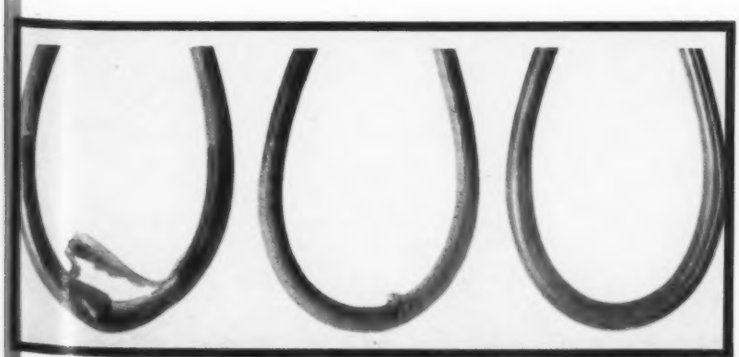
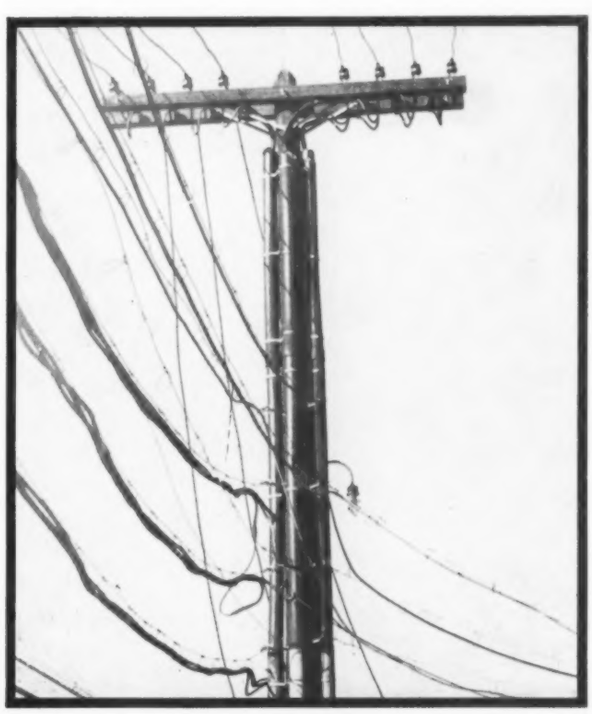


**Figure 5 — (right) Cables are also tested in pole riser and messenger installations in the proving ground.**



## TABLE II

| Name | Chemical type | Remarks | Use | Electrical properties | Chemical properties | Resistance to ozone and sunlight | Physical properties | Non-inflammability | Oil resistance |
|---|---|---|---|---|---|---|---|---|---|
| Neoprene | Chloroprene polymer | Vulcanizable. Rubber-like. Extrudable or calendered strips. Several types. | Insulation or jacket | P | E | E | G | E | G |
| Perbunan | Butadiene polymer | Vulcanizable. Rubber-like. Copolymerized with acrylonitrils. Extrudable or calendered strips. | Jacket | P | F | P | G | P | G |
| Hycar OR | Butadiene polymer | Vulcanizable. Rubber-like. Copolymer. Extrudable or calendered strips. | Jacket | P | F | F | G | P | G |
| Hycar EP | Butadiene polymer | Vulcanizable. Rubber-like. Copolymer. Extrudable or calendered strips. | Insulation | G | F | F | G | P | F |
| Chemigum** | Butadiene polymer | Vulcanizable. Rubber-like. Copolymer. Extrudable or calendered strips. | ..... | P | E | P | G | P | G |
| Buna S* | Butadiene polymer | Vulcanizable. Rubber-like. Copolymer with styrene. Extrudable. | Insulation | G | G | F | E | P | F |
| Vistanex | Isobutylene polymer | Not vulcanizable. Rubber-like. Mixed with resins or rubber. Extrudable. | Insulation | E | E | E | F | P | P |
| Styron | Styrene polymer | Thermoplastic. Not extrudable. Threads on tapes. | Insulation | E | E | E | E | P | P |
| Polystyrene-rubber* | Styrene polymer with rubber | Mix with rubber and vulcanize. Extrudable. | Insulation | G | E | G | G | P | P |
| Polythene* | Ethylene polymer | Thermoplastic. Extrudable. | Insulation | E | E | E | E | P | F |
| Butyl rubber* | Hydrocarbon polymer | Vulcanizable. Extrudable. | Insulation | G | E | E | F | P | P |
| Thiokol | Organic polysulphides | Both thermoplastic and vulcanizable types. Extrudable. | Jacket | P | G | E | F | P | E |
| Koroseal | Plasticized vinyl chloride polymer | Thermoplastic. Extrudable. | Insulation or jacket | F | E | E | G | E | E |
| Vinylite | Plasticized vinyl chloride polymer | Thermoplastic. Extrudable. Copolymer with vinylacetate. | Insulation or jacket | F | E | E | G | E | E |
| Saran | Vinylidene chloride polymer | Thermoplastic. Applicable as threads or tapes. | Insulation | F | E | E | G | E | E |
| Tenite II | Cellulose derivative | Thermoplastic. Extrudable. Cellulose-acetate-butyrate. | Insulation | F | G | G | G | F | G |
| Ethyl cellulose | Cellulose derivative | Thermoplastic. Extrudable. | Insulation | F | G | G | G | F | G |

LEGEND

*Being produced commercially in the United States or plants being built for production.
**Entire production now being absorbed by manufacturer.
E — EXCELLENT
F — FAIR
G — GOOD
P — POOR

Electrical properties include dielectric strength, capacity, power factor, insulation resistance, etc.
Physical properties include tensile strength, elongation, modulus, toughness and abrasion resistance.
Chemical properties include resistance to oxidation, acids, alkali, and moisture.

limitless and include station cables of all types, generator and transformer leads, control wiring, railroad signal wiring and a wide variety of wires for industrial service. Table I gives the characteristics of both the oil-base insulation and the neoprene sheath and will indicate the many problems that this type cable can solve.

Among the other synthetic materials are the isobutylene polymers which have made possible low capacity insulations for use in high frequency circuits up to 400 megacycles. This type cable is finding wide use in long range plane detecting devices, a very recent development for the war program.

Showing great promise are the so-called butadiene polymers (like the famed buna "rubbers") which are commercially the easiest to produce and they will soon be available in large quantities. They have proved valuable in the mechanical rubber field but as yet are only in an experimental stage in the wire and cable research laboratories.

Thiokol, another synthetic in use for nearly a dozen years, is frequently used as a jacket. Its exceptional resistance to oils has made it a desirable covering for cables in use in refineries, garages, machine shops and other locations where oil is prevalent. Thiokol is an extremely moisture-resistant material and has also been used to protect underground cables, especially those used on d-c circuits where electrolysis conditions make lead sheaths impractical.

Table II gives a broader picture of the synthetics that may become more and more prominent in the wire and cable industry. Their more important characteristics, as listed, indicate their possibilities for the near future. These data are based on the results of investigations made in the Okonite Research Laboratory.

Research on these materials continues and, though many applications and uses have already been found for synthetics in the wire and cable industry, the surface has merely been scratched. The future will see them in greater and greater use — not only since rubber is scarce, but because of the increasing supply, the decreasing costs, and the inherently good characteristics of these new materials.

# FISCHER *Discussion*

(*Continued from page 60*)

since December, 1940. We have found that these high pressure machines are just as reliable and just as easy to operate as any low pressure machine in the plant. The boilers supplying these turbines present no added problem other than correct feed water treatment over the low pressure plant. The governing of these back pressure turbines has worked out very well because practically all fluctuations in load are carried on the high pressure generators. The high pressure boilers supplying these generators with steam are the only ones in the plant normally burning coal. The other boilers operating at 225 lb pressure are normally using waste fuels or waste heat so that any increase in steam demand must first come from the high pressure boilers through the back pressure generators, thence into the 225 lb system.

We have found with the high pressure turbines on the line, we are able to govern better than before we had them. One of the reasons for this is that a high speed back pressure machine takes about twice as much steam per kilowatt as the low pressure machine, so that when there is an increase of 2000 kilowatts on the high pressure unit, there is enough steam exhausting out of it to make 4000 kilowatts on the low pressure unit without a change in the steaming rate of the low pressure boilers. On these machines the governors are reliable. Our schedule of taking the generators off the line for inspection is once in two years, and we have found that these high pressure units at 800 lb pressure have worked out very satisfactorily.

**F. K. FISCHER:** It is very gratifying to find the several discussers in general agreement with this paper.

The advantages of hydrogen cooling of generators as pointed out by Mr. Thomas is a welcome addition to the paper. These advantages plus the several years of thoroughly successful operating results, have solidly established hydrogen as the accepted coolant for generators in all ratings above 20,000 kw.

Mr. Tucker's description of the design of the low pressure rotor of the 147,000 kw tandem turbine should be interesting to steel engineers as well as turbine engineers. This construction shows the important position weldings plus non-destructive methods of test, such as the use of gamma-rays, play in the fabrication of present day designs.

Mr. Stott points out that if the steel industry in general adopts high pressure and temperature units they must be prepared to make the necessary improvements in boiler feed water and general operating conditions. This is very true, however, with the several years operating experience behind us we can safely say that adequate experience has been gained and the procedure for handling these problems is well in hand. In commenting on operating experiences with an 800 lb, 825 F plant, Mr. Strassburger comments as follows: "The boilers supplying these turbines (800 lb, 825 F) present no added problem other than correct feedwater treatment over the low pressure plant."

The question of excessive exhaust temperature for extended operation at no load, when using high initial pressure and temperature is brought up by Mr. McArthur. This temperature will depend on initial steam conditions, exhaust vacuum and turbine design. For a 1200 lb, 900 F condensing machine at no load and reasonable vacuum, temperatures of the order of 300 F to 400 F rather than 600 F to 700 F would be expected. However, this temperature is higher than manufacturers recommend and good operating practice permits, which means very light load operation should be avoided. The high pressure and temperature boilers help out in this respect as they normally have a drooping temperature characteristic with reduction in load.

Mr. Strassburger comments on his general satisfactory operating experience on two high pressure 3600 rpm units. His satisfactory experience with the high pressure and temperature units is typical and can be summed up best as expressed by Mr. Strassburger: "We have found that these high pressure machines are just as reliable and just as easy to operate as any low pressure machine in the plant."

# Welding Metallurgy

***. . . . the welding of steel brings in many of the fundamentals of metallurgy . . . . designing for welding, preheating and stress relief all embrace problems similar to those encountered by the steel mill metallurgist . . . .***

*by W. G. Theisinger*

DIRECTOR OF WELDING RESEARCH

**LUKENS STEEL COMPANY**

COATESVILLE, PENNSYLVANIA

▲ THE problems encountered by the welding engineer are indeed similar to those dealt with generally by the steel mill metallurgist. Both have a common ground on which to meet for a discussion of mutual variables and similar fundamentals. The melting of steel or the deposition of weld metal presents like characteristics in the selection of raw materials or base metals, and each treats the behavior of cast metal in moulds, as well as the rate and manner of the individual melt's solidification. The comparison may be carried on through many of the succeeding steps to illustrate that the resulting stresses, chemical composition, physical properties and heat treatment parallel each other in many ways, but the analogy should be definitely stopped at this point to return to one of the most important factors, namely the mould, and show that even though the process performed is the same for both casting and welding, the purpose of each is of necessity entirely different.

The bonding of molten steel in contact with a cold, solid material depends upon the quantity of the melt, its temperature, the force or penetrating power applied to the molten metal being cast and the temperature and thickness of the surrounding mould. In the pouring of molten steel in the open hearth from the ladle to the ingot moulds, the mould walls are selected for their thickness depending upon the amount of melt being poured. In all cases the mould wall is sufficiently heavy to chill the skin of the melt in contact with the mould quickly enough to prevent welding of the melt to the mould. Likewise the moulds are maintained at normal temperatures before pouring to assist in this chilling effect. While the body of the cast ingot will remain molten for several hours, the fact that the outer layer of the ingot solidified quickly, prevents any tendency of the interior molten metal to bring about a joining of the ingot to the mould. Once this sudden chilling of the outer surface of the ingo has occurred, any bonding of it to the mould has been definitely overcome. As steel in the molten condition occupies a greater volume than when it is in the solid state, the ingot by contracting shrinks away from the mould wall, which makes it possible to strip the mould from the ingot. If the mould walls were very light in thickness or excessively hot, the chilling of the surface of the molten steel would not take place and the result would be a union of the melt with the mould. Later solidification with its resulting shrinking would distort the mould and, of course, make it impossible to remove the ingot from the mould.

The welder seeks to bring about just the opposite effect by having his deposited melt combine firmly and permanently to his "mould." The sides of the "U" or "V" groove make up the welder's mould wall. Bonding during welding is assisted to a great extent by the penetrating power of the arc combined with the reaction of the arc which raises to a molten temperature both the metal being melted from the electrode and the metal melted from the base plate. Therefore, both metals, the electrode and the base plate contacted by the arc, are raised to the molten state and the deposited or poured, molten metal is a combination of added metal and mould. If the base metal is light in cross-section, the heat gradient is gradual from the fusion line into the base plate and sudden cooling of the "skin" of the deposited metal cannot occur. This produces the perfect joining of the deposited metal and the base plate. The shrinkage of the molten metal in the weld and the temperature gradients across the joint in light plate causes distortion which is apparent as warping; or the restraint of the design is such as to prevent warping and then these cooling factors set up stresses, referred to as residual stresses in welding. The welding of light gauge, mild steel assemblies presents few problems in this connection and it becomes evident that such difficulties appear with increasing thicknesses of the base plates to be welded.

Presented before A. I. S. E. ANNUAL CONVENTION, Pittsburgh, Pa., Sept. 22-24, 1942

The heavier the thickness of the plates being welded, the greater the chilling effect on the deposited metal and the greater the possibility of lack of fusion between the melt and the "mould" or base plate.

In order to reduce the quenching rate brought about by the rapid cooling of the weld metal at the fusion line of the welded joint, it has been generally recognized that preheating of the base plate is helpful, and indeed necessary. As the term preheating signifies, the plates to be welded, particularly in the region of the joint, should be warmed before any welding is done. This preheating temperature should be maintained during the welding operation, but the supply of external heat may be diminished as the heat from the application of the welding operation itself increases. In other words an allowance should be made to hold the preheating temperature by a combination of external heat, such as from a flame. From the start of the welding process until the joint is completed, the temperature in that area should be within reasonable limits as uniform as possible. If there is a delay during welding at which time the operator is not working, it is desirable to hold some heat in the vessel during the idle period. This is not always necessary, but when a delay occurs, the vessel should always be preheated before welding is continued if it has cooled down to any appreciable extent.

The question has arisen many times in the welding of heavy plate as to the amount of heating that should be employed before and during the welding of the structure. Naturally the answer depends upon the chemical composition of the steel base plate, the rigidity in or near the joint and the thickness of the plate. In regard to chemical composition the greater the amount of carbon or other alloying element, which contributes to an increase in hardening power following sudden cooling, the higher the temperature needed to diminish this hardening effect. This signifies that the heat affected or hardened zone in the plate adjacent to the weld is a contributing factor to lack of fusion, although it is more closely associated with the possible formation of cracks in the vicinity of the fusion line. Since the interest is centered in this fusion line area, any formation of cracks due to such a cause should be taken care of by the outline of procedure before the welding is started. This can be done by preheating which will reduce the quenching or hardening effect on the plate metal. A great number of research and practical problems have demonstrated that the greater the heat energy input, the lower the hardening or quenching rate.

Preheating is beneficial where the joint to be welded is rigidly confined in the structure, and the more rigid the design the greater the extent and degree of preheating needed. For example, a small test plate of any thickness may be welded with little regard for any of these factors, since it is free to move under the contracting stresses, and very quickly builds up heat from the welding process. As the dimensions of the plate increase or members are added such as stiffeners, blocks, etc., in the vicinity of the weld, preheating becomes increasingly essential.

From the standpoint of actual fusion between the base plate and the weld, the thickness of the plates being welded is a controlling factor. Heavy plate increases the tendency to quench the deposited metal especially in the fusion zone where the "skin" may be cooled so quickly that it does not bond to the plate, and the open hearth mould effect enters the picture as discussed earlier. Of course, any increase in hardening power due to the chemical composition of the plate augments the tendency for this type of lack of fusion. In regard to the physical and chemical properties of the steel being welded, it is often difficult to have the operators appreciate the significance of even slight increases in carbon or other alloying elements. The difficulty arises from the fact that 0.20 per cent or 0.40 per cent carbon in steel makes the difference between a readily weldable steel and one which may present a difficult problem. It is reasonable to expect that many operators would overlook the slight variation of 0.20 per cent of any element as making the difference between success or failure of their work. For this reason, a discussion of chemical or physical properties would only confuse instead of clarify the problem, and it has been suggested and practiced that some rule of thumb means be used to bring this heavy plate factor forcibly and readily to the welder's attention.

A value of 100 F preheat for each inch of plate thickness has worked satisfactorily and is readily understood by everyone. It simply means that a one inch thick plate should be heated to 100 F, before starting to weld, and should be maintained at approximately that temperature during welding. Likewise a plate two inches thick should be kept at 200 F, and a four inch thick plate should be welded at 400 F. Reasonable interpretation of such a rough guide is of course to be expected, but it does definitely emphasize the need of heat in heavy plate during welding. If a one inch thick plate is being welded, it may be only necessary to preheat prior to welding if the passes are deposited at frequent intervals, as the welding heat alone will be sufficient to maintain the 100 F temperature required. On the other hand, a four inch thick plate would require preheating and subsequent heating during welding to maintain the suggested 400 F temperature.

This does not mean that a ¼ inch thick plate of 50,000 lb yield strength may be welded at 25 F, without fear or failure. Due consideration must be given in such a case to the physical properties and the design of the weldment. In this instance, a temperature of 100 F would be desirable. Earlier work has indicated that welding at a temperature less than 50 F is dangerous; but in order to be on the safe side this low temperature should be avoided. The practical significance of how small changes in temperature affect the success of the welded joint has been demonstrated by the variations in results obtained by work done in summer or winter temperatures, where the range may only vary from 80 F, down to freezing or slightly below. Therefore, the operator dare not disregard the temperature of the material being welded any more than he can overlook the composition of the plate metal or the welding electrode.

As an added precaution, the adoption of a sequence of welding is extremely helpful in the welding of thick plate. The old back-stepping methods are still useful, and sequence of beads should be considered where the factors of heavy plate, rigid design or chemical composition are present. In any event, keeping the plate warm during welding is one of the easiest methods to

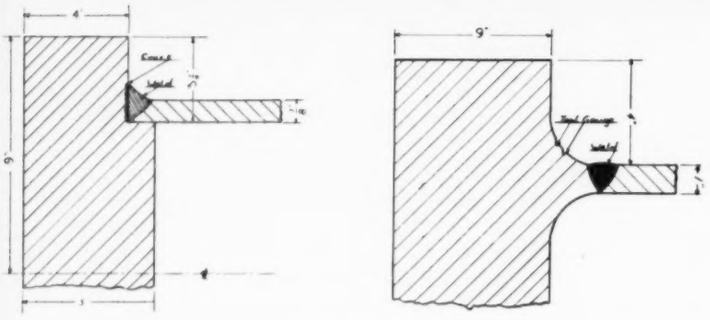


**Figure 1 — (left) Sketch showing a practical effect of thickness in the welding of heavy plate.**

**Figure 2 — (right) Dissimilar sections adjacent to the welded areas may result in failure of heavy plate construction.**

use and one of the first to be thought of in the fabrication of heavy plate.

Preheating and the maintenance of such heat for welding can be carried out by a number of practical means. The easiest way is to insert a gas pipe containing a series of holes for jets into the interior of the vessel or underneath the joint itself. The flame can be regulated to give the proper supply of heat and to decrease the supply as the temperature of welding increases. This is an inexpensive method of overcoming costly cutouts and repairs due to this type of bond failure.

An obvious objection may be the discomfort to the operator that such heat may cause. Fortunately most welds are of the single "U" type where 75 to 90 per cent of the welding is done from one side. In the case of boilers or pressure vessels the major portion of the groove is on the outside of the vessel. The pipe line for heating is placed inside the vessel during the welding of the groove, which is on the outside away from the heat. When this portion of the weld is completed, the vessel is allowed to cool to room temperature, and the chipping and welding on the inside of the shell may be done at room temperature. If the surrounding atmosphere is extremely cold, the vessel should be warmed to a comfortable temperature, in the vicinity of 80 F, while the welding is being done on the inside of the vessel. Usually only three or four beads are required on the inside, and since the joint is almost completed by the outside portion that has already been welded, no difficulty has been experienced from the welding of the inside of the vessel at a normal temperature.

The weldment in Figure 1 illustrates a practical effect of thickness in the welding of heavy plate. This assembly also combines a rigid design, as well as the welding of a high tensile steel material. A relatively light web plate, 7/8 inches thick, was welded to a four inch thick rim that had been machined in parts from its original five inch rolled thickness. The lighter plate had been beveled with a 45 degree angle, and the joint between the web and rim welded by depositing a series of multiple hand passes in the groove. The welding was done under normal conditions and temperature with apparent satisfactory results until near the end of the final welding when a crack was noticed in the fusion line between the weld and the heavy plate rim. Chipping revealed that the crack extended to the full depth of the weld and remachining showed that the weld metal that had been deposited into the heavy rim had failed to bond to that plate. In other words, the "skin" of the deposited weld metal had been chilled so quickly by the heavy mould wall that it had not had an opportunity to fuse, but tore away during subsequent shrinking. No such difficulty occurred on the web which was much lighter plate than the rim section. The weldment was rewelded satisfactorily by keeping the entire structure at a temperature of 400 to 500 F, until the welding was completed.

A somewhat similar chilling effect may result in failure of heavy plate construction in the design shown in Figure 2. In this case a section of a heavy plate header had been machined to form a lip which was to be welded to a shell plate. While the thickness of the rolled shell plate and the welding lip on the header were the same, in the areas to be welded, the sections of each adjacent to the weld were dissimilar. The thickness of the shell was uniform throughout its length and the temperature gradient was gradual away from the weld into the shell. However, the thickness of the lip on the header increased rapidly over a short distance so that the temperature gradient would be particularly steep in the radius between the edge of the lip and the header. Within this area the quenching effect of the heavy plate would be brought to bear and a fairly rapid cooling rate could be expected. The contraction stresses across such a joint and the uneven cooling rate can be alleviated by preheating and by keeping this area warm during welding. This particular illustration shows the several factors of cooling, shrinkage and stress raising ability of notches, and their combined effect on the structure. In any event, the machining should be carefully done in this area so that notches will not be present, but particular attention should be given to permit more equal heating and cooling rates where dissimilar thicknesses have to be joined together by welding.

## STRESS-RELIEVING TREATMENT

The stress relieving treatment used for certain types of weldments follows the procedures ordinarily employed in the heat treatment of steel, with the exception that the temperatures are somewhat lower. In most cases the entire structure is subjected to this treatment, which limits the application of stress relieving of a number of weldments because of their size. The temperature gradients and the restraint imposed on the weld metal after it is deposited produces stress which industry has found advisable to remove or reduce in order to insure safe operating conditions in service. For a number of different uses, the various regulating codes and specifications require that the stress relieving treatment be given to the vessel after welding. Stress relieving imparts a beneficial effect which is recognized in design, and due allowances are credited for its use. When the service stresses are relatively low, stress relieving is not usually required.

The stress relieving treatment as applied to welding structures is performed by placing the structure or vessel into a furnace and slowly heating it to 1150 to 1200 F, and holding at that temperature for a length of time depending upon the greatest thickness of any section in the vessel. The established holding time is one hour per inch for the maximum thickness. Following this soaking time, the vessel is allowed to cool in the furnace to a temperature of approximately 600 F, and may then be removed from the furnace to cool in still air to room temperature. This treatment develops a more uniform structure by relieving the effects of welding such as the stress created, the hardness of the affected zone of the plate adjacent to the weld, and the elimination of any dissimilar microscopic constituents in this area.

A number of experiments have been conducted to quantitatively measure the residual stresses produced by welding, as well as the effect of the stress relieving treatment. One such method is shown is Figures 3 and 4, where Figure 3 illustrates the stress gradients and the amount of stress in the as-welded condition, and Figure 4 shows the results of stress relieving this same welded plate. While the results illustrated cover automatic welding, like tests and values were obtained on hand welded plates.

Two low-carbon, structural grade, rolled steel plates were beveled, tacked and butt welded together. The welded plate was 36 in. x 24 in. x 7/16 in. After welding and cooling to room temperature, small tapered holes were drilled into both surfaces of the plate directly opposite each other through the thickness. Two sets of such holes were spaced across the plate, transverse to the direction of welding and about 1/4 in. apart through the welded area. There were four series of these pairs of holes across each plate. The distance between holes in a direction parallel to the direction of welding was measured with an extensometer reading to 1/10,000 inch. Readings were taken on both sides of the plate. Following these measurements, the plate was cut into strips, each about three inches wide so that each strip included a parallel set of holes. This removal of the section produced an elastic yielding so that the difference between the previous readings and the ones now made on the strip indicated the stresses produced by the welding operation on the plate specimen.

The values obtained for the automatic welds are shown in Figure 3, indicating that the center line of the weld, in the as-welded condition contained a residual stress in the order of 46,000 psi. The slope of the stress curve illustrates the steep stress gradient extending from the center line abruptly into the plate away from the weld. The negative values are those above the zero line showing that the particular area had actually

**Figure 3 — Stress gradients in automatic welds (as-welded condition). −=shortening, +=lengthening. Each unit=400 lb, average of two faces. Measurements are parallel to weld.**

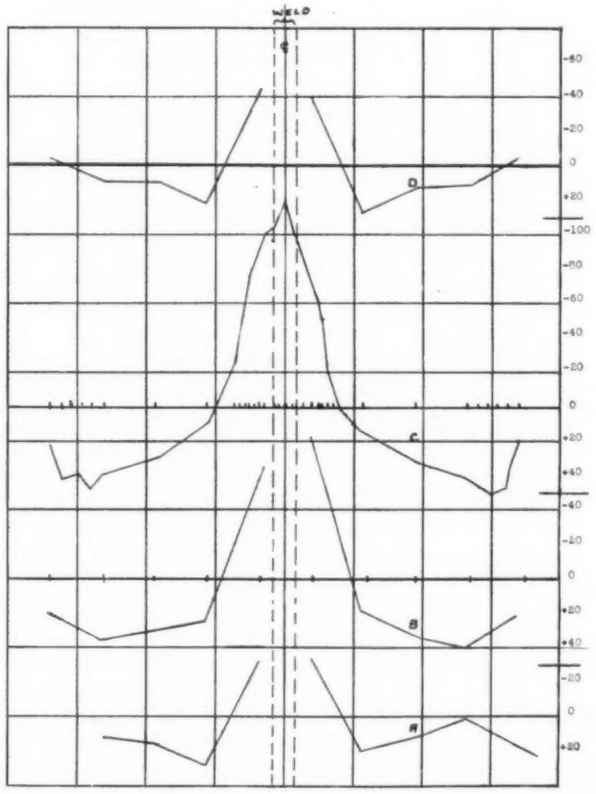
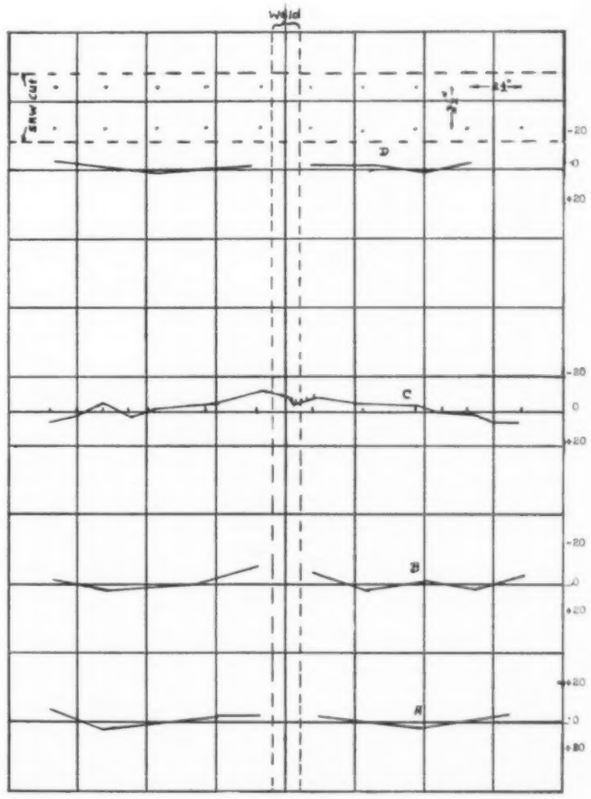
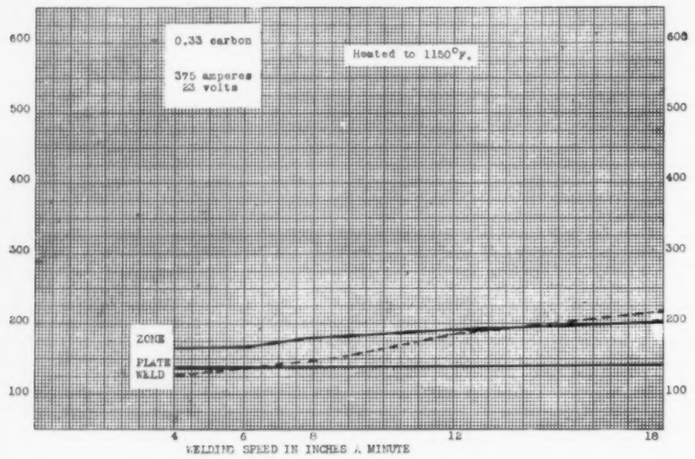



**Figure 4 — Stress gradients in same welded plate of Figure 3 after stress relieving.**






shortened in length by the removal of the specimens from the welded plate and that tension in the weld is clearly indicated. The positive values are those below the zero line and represent compressive stresses. The three other lines on the same chart were not carried to completion through the weld, but show the trend of the stress gradients in the affected area.

A similarly welded plate sample was prepared and welded, but stress relieved after welding. The same kind of measurements were taken and the stress gradients on this heat treated plate are shown in Figure 4. It is evident that stress relieving has produced the desired effect by doing exactly what was intended in that the stresses were relieved by a reduction of the originally as-welded stress values of 46,000 psi to the safe value of approximately 4,000 to 5,000 psi. The relief of the welding stresses and the reduction of the steep stress gradients were performed by the heat treatment. There may be some question as to the actual values, but the trend of the results is definitely clear. The stress picture across the welded joint is uniform after stress relieving.

In addition to the effect on the relief of stresses, this heat treatment also reduces the hardness in the heat

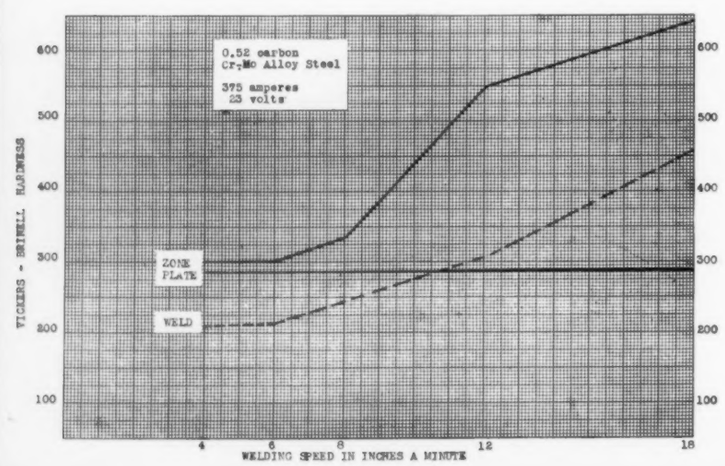
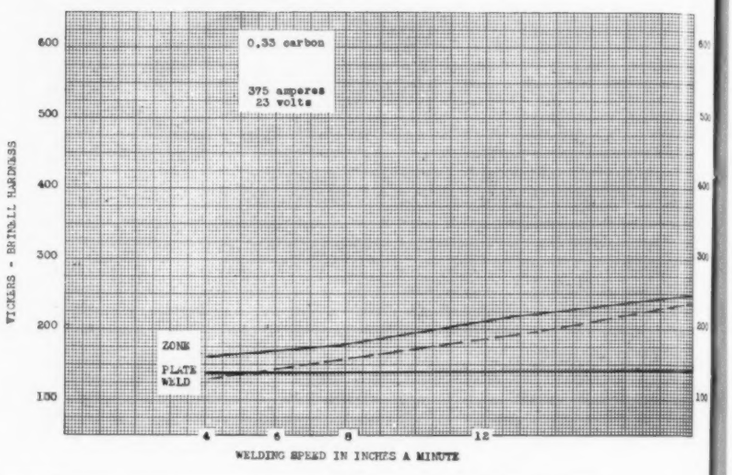



**Figure 5 — (left) Chart showing hardness of SAE-1035 unaffected plate and hard zone adjacent to weld.**

**Figure 6 — (below) Hardness values of the same specimens used in Figure 5 shows a general reduction and greater uniformity.**




affected zone adjacent to the weld in proportion to the original hardness in the as-welded condition. In other words the higher the hardness, the greater the reduction in hardness due to stress relieving. Again the trend to equalize the hardness of the weld and plate across the joint is indicated.

A 0.33 per cent carbon steel (SAE 1035) was welded with constant conditions, with the exception that the

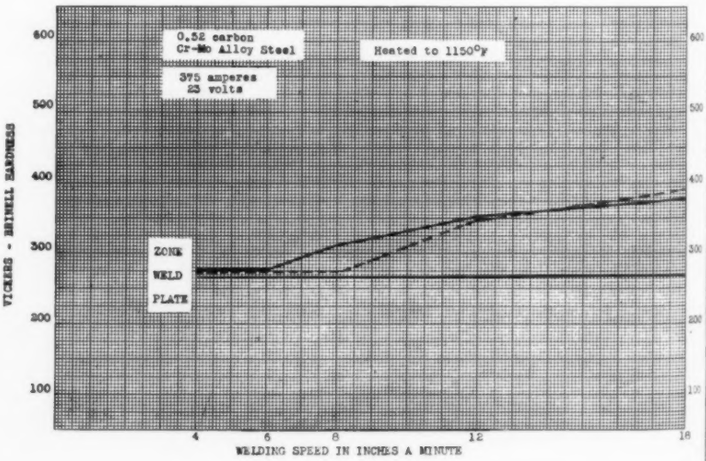



**Figure 7 — (left) With SAE-4150 steel, the hardness of the heat affected zone increases considerably over the hardness of the plate itself.**

**Figure 8 — (above) Stress relieving of SAE-4150 steel is more definite than with a low-hardening steel.**

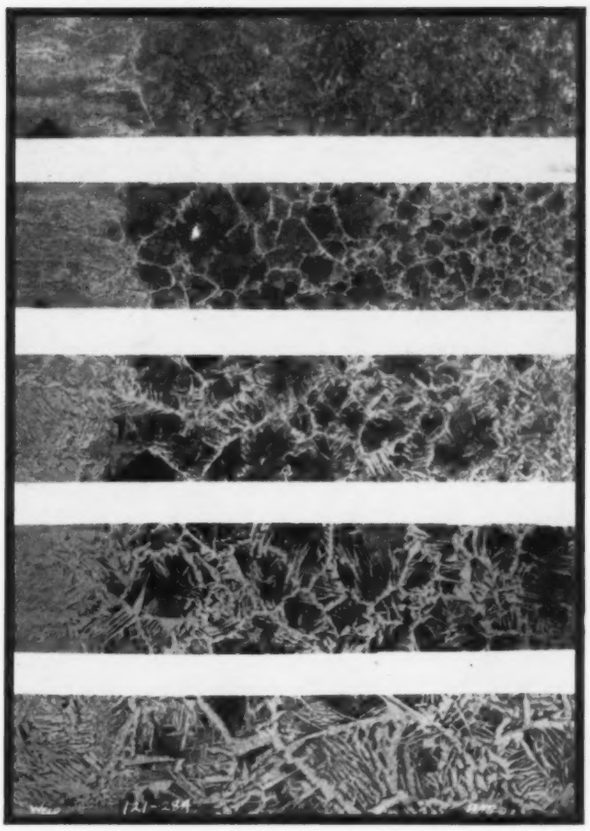


**Figure 9 — Photomicrographs of the SAE-1035 plate specimens showing the heat-affected zone and a portion of the weld.**

welding speeds of 4, 6, 8, 12 and 18 inches a minute were employed to show the effect of the hardening in the metal adjacent to the weld by the different rates of cooling as the welding speeds were increased. Figure 5 shows the hardness of the unaffected plate and the hard zone adjacent to the weld for the welding speeds from 4 to 18 inches a minute. At the slow speeds, the difference in hardness between the plate and the hard zone was very small, but at the faster welding rates the difference is more marked. The maximum hardness is 250 Brinell. The same set of specimens was stress relieved according to the usual procedure and it is noted that the hardness values of both plate and hard zone are more uniform. The maximum hardness is 200 Brinell, as shown in Figure 6. Thus, stress relieving has reduced the hardness from 250 Brinell in the as-welded condition to 200 Brinell after stress relieving.

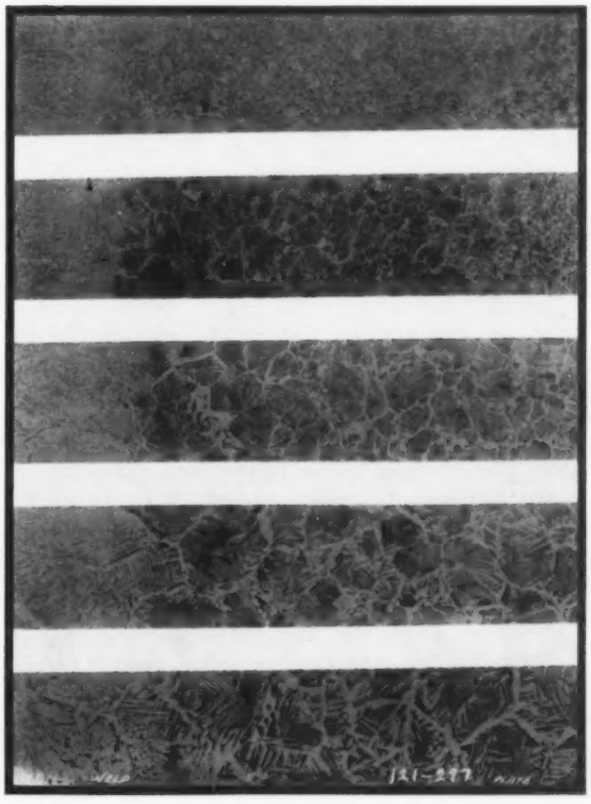
The same relationship occurs in the more readily hardenable steels such as the SAE 4150 steel shown in Figure 7, where the maximum hardness in the as-welded condition is 642 Brinell, or a considerable increase over the hardness of the plate itself of 285 Brinell. The stress relieving treatment of this type of steel is more definite, as there was a greater hardness to begin with, and the treatment reduces the maximum hardness to 375 Brinell as shown in Figure 8. Thus an equalizing result is obtained in hardness as well as stresses.

Stress relieving is also a corrective treatment for any harmful microscopic constituents that may be present, although the temperature is not high enough to cause any changes in the normal structures such as the pearlitic and sorbitic types. Since martensite and troostite are not stable at 1150 F, they change over to the more ductile and serviceable sorbitic or pearlitic structures. As pearlite and sorbite remain unaffected by the 1150 F temperature, they remain in their original condition.

This is indicated by the photomicrographs of the SAE 1035 steel of Figure 9, showing the heat affected zone and a portion of the weld for the 4, 6, 8, 12 and 18 inch welding speed samples. The structures are pearlitic to sorbitic and remain, as shown in Figure 10, after stress relieving unaltered from the as-weleded condition. However, the hardenable steel, SAE 4150 at the various welding speeds shows pearlite to troostite and martensite, Figure 11. It is to be expected that martensite would be formed where the hardness is 642 Brinell. However, stress relieving reduces these objectionable constitutents to sorbite, as illustrated by Figure 12, where the martensite and troostite have been changed over to the more ductile sorbite.

Thus, stress relieving has shown itself to be an equalizing treatment for stresses, hardness and microscopic constituents. It has removed the questionable factors that might influence the service life of the welded vessel. Preheating and stress relieving are beneficial treatments that are inexpensive to apply, yet may result in considerable savings in cost and service use.

**Figure 10 — Photomicrographs of the SAE-1035 steel after stress relieving show the pearlitic-sorbitic structure of Figure 9 to remain unchanged.**



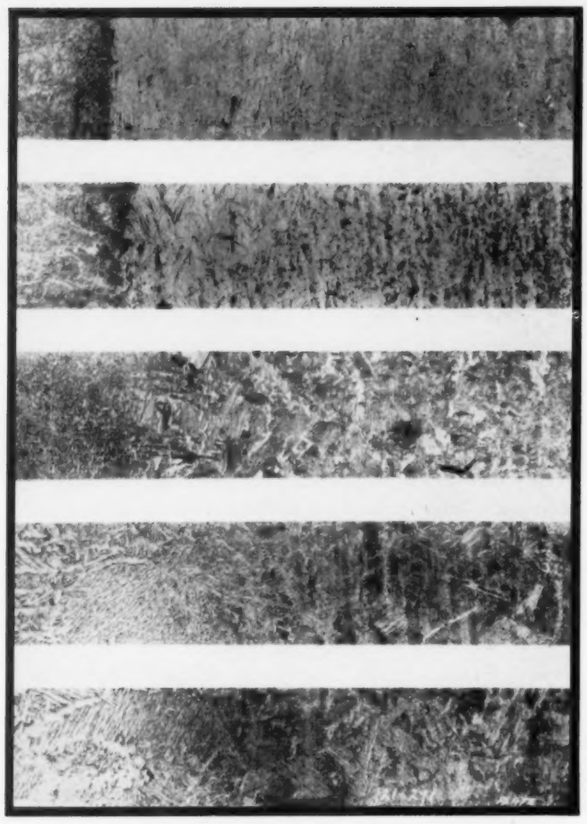


Figure 11 — Photomicrographs of SAE-4150 steel in the as-welded condition show troosite and martensite.

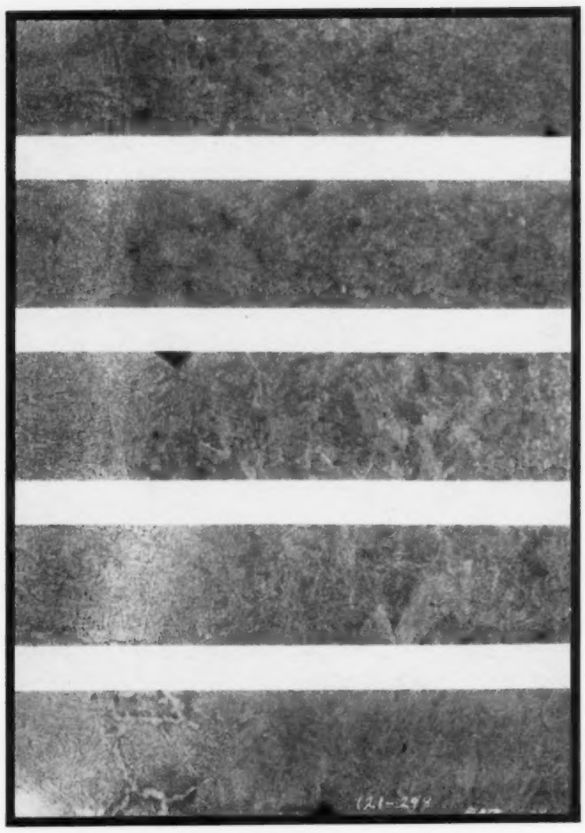


Figure 12 — The stress-relieving treatment reduces martensite and troosite to sorbite.

## PHYSICAL PROPERTIES

One of the common problems in welding has to do again with the uniformity of the welded joint, in particular the physical properties of both plate and weld metal. Specifications have considered this point by requiring tests to bring out the similarity in physical properties, or marked differences if present. In the usual metallurgical practices the attainment of high tensile steel is accomplished at the sacrifice of ductility. Such a condition is revealed by a high tensile steel with low elongation or reduction in area values. There has been a tendency at times, especially at the beginning of the adoption of weld tests methods to select a welding rod that would be much higher in tensile strength than that of the plate, so that the specimen would always break outside of the weld when tested in tension. This would give some indication of the high tensile properties of the weld, but would not reveal its probable low ductility. The specifications have generally taken this into account by stipulating that an all-weld metal specimen be removed from the weld metal only, in the joint so that its true physical properties could be obtained, in addition to those properties across the joint in the transverse reduced section tensile test.

To the fabricator, ductility of the weld metal is not as important in the completed joint after the stress relieving treatment as it is in the weld itself while the joint is being made. It is during fabrication that the ductile weld metal will withstand the cooling strains much better than the harder and less ductile weld metal of a higher tensile strength weld. The codes have set a minimum tensile strength for the weld metal in accordance with the strength of the plate material in the vessel. They have also required a minimum elongation to insure that there is sufficient ductility and that this property has not been sacrificed in order to obtain the required strength.

This uniformity across the joint should be given particular attention in the welding of high tensile steels, for example the 70,000 to 82,000 psi material. This steel is made in accordance with A. S. T. M. specification A-212 or A. S. M. E. specification S-55. The electrode manufacturers have adopted chemical compositions in the metal deposited from their electrodes that when properly applied will meet the tensile and ductility requirements in the weld equal to those of the plate metal. As an illustration, Table I shows a typical test report of heavy plate and weld metal in a production weld test plate of high tensile strength carbon-silicon steel plate of A. S. T. M. A-212 or A. S. M. E. S-55.

The physical properties are practically identical in regard to tensile strength and ductility and assures the fabricator and user of a uniform joint in the vessel. It is to be noted that the electrode maker, in keeping with the desire for low carbon in the weld metal adopted a small amount of an additional alloying element to

## TABLE I

| | Tensile strength, psi | Yield point, psi | Remarks |
|---|---|---|---|
| 2½ in. plate material (stress-relieved) | 77,600 | 46,900 | 28 per cent elongation in 8 in. |
| .505 all-weld material | 77,000 | 61,250 | 30 per cent elongation in 2 in.<br>62.3 per cent reduction of area |
| Reduced section (stress-relieved) | 76,780 | 46,000 | Fracture at edge of weld |

| | C | Mn | P | S | Si | Mo |
|---|---|---|---|---|---|---|
| Plate | .27 | .72 | .016 | .024 | .23 | .... |
| Weld | .09 | .51 | .021 | .017 | .19 | .57 |

obtain the desired tensile strength and still maintain the ductility.

The application of the fundamentals of metallurgy and many of the practices common in steel mills are interesting and helpful in the application of welding to steel. They can assist the operator in obtaining a better understanding of the problems and procedures he encounters.

# DISCUSSION

**PRESENTED BY**


**C. H. JENNINGS, Research Engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania**

**A. E. GIBSON, President, The Wellman Engineering Company, Cleveland, Ohio**

**G. C. EHEMANN, JR., General Foreman, Maintenance Department, Carnegie-Illinois Steel Corporation, Duquesne, Pennsylvania**

**WRAY DUDLEY, Assistant Superintendent of Maintenance, National Tube Company, McKeesport, Pennsylvania**

**W. G. THEISINGER, Director of Welding Research, Lukens Steel Company, Coatesville, Pennsylvania**

**M. M. MacDONALD, Electrical Superintendent, Andrews Steel Company, Newport, Kentucky**

**J. H. COOPER, Welding Engineer, Taylor Winfield Company, Warren, Ohio**

**F. C. SCHOEN, Assistant Master Mechanic, The Midvale Company, Nicetown, Philadelphia, Pennsylvania**


**C. H. JENNINGS:** Dr. Theisinger is to be congratulated on his very excellent paper which covers certain phases of weldability which are often given little consideration. The proposed rule-of-thumb method of determining preheating temperatures requires further consideration however.

Preheating is helpful and often desirable when welding thick plates, and the higher the carbon or alloy content the more important it becomes. Low carbon steels in general do not require a great deal of preheat although warming to 90 F is highly desirable.

The proposed rule of 100 F preheat per inch of plate thickness appears to be excessive. Many structures containing low carbon steel plates 6 to 8 in. thick have been welded with preheat temperatures no greater than 90 F. Application of the 100 F per inch of thickness rule would have resulted in preheat temperatures of 600 to 800 F. Such high temperatures would have been unnecessarily high and would have resulted in discomfort to the welding operator, lost time and unnecessary expense.

Unless the structure is very rigid, or is composed of medium carbon, high carbon or alloy plates there is generally little reason to preheat above 90 F. With low carbon steel structures preheats of 150 F are probably the highest that are ever required.

I would like to make another comment in connection with preheating. Preheating a structure before welding may be done for several purposes:

1. To obtain better fusion to the thick plates when welding light and heavy plates together.

2. To reduce the quenching effect in the heat affected area and thereby reduce the hardness in the area adjacent to the weld.

3. To reduce the distortion and residual stresses in the completed structure.

The reduction of distortion and residual stresses is probably the primary reason for preheating low carbon steels which do not harden greatly as the result of welding. Distortion and residual stresses are the result of weld metal shrinkage and non-uniform heating and cooling of the structure as a result of welding. Preheating reduces the non-uniform heating and cooling, consequently, it reduces the distortion and residual stresses obtained. The higher the preheat in such cases the better are the results obtained.

**A. E. GIBSON:** I would like to add a comment on heat treatment of weldments which I think will be of interest. In the early days of the development of low

alloy steels we were using Cromansil steel in the manufacture of heavy clam shell buckets for the steel mill trade. These buckets are subjected to very high and unpredictable loads, particularly impact. During this period we carried on considerable investigation of this material in tensile, bend, impact, fatigue and grain structure under various heat treatments.

We wished, if possible, to produce a normalization of the weldment but appreciated that taking large welded structure out of the oven and air cooling from approximately 1600 F was liable to set up cooling strains due to the various sections of metal thickness. We adopted a method which called for slow heating to 1600 F, a fair soaking period in a pit annealer. The heat was then turned off, the pit cover removed and the temperature lowered as rapidly as possible through the critical range to about 1000 F. The cover was then replaced and the work allowed to cool to approximately room temperature. We carried test pieces with the weldments and the complete penetration weld test piece — welded with a molybdenum electrode — produced an elongation of 83 per cent in the outer fibres of the 1½ in. thick bend test piece. We had never before known of so high elongation in a bend test.

The Cromansil plate was 1½ in. thick, the carbon content .15 per cent. Very satisfactory yield and tensile strength of the weld were obtained but somewhat less than that of the plate.

We have since discontinued this treatment in favor of stress relief at 1100 F because of the cost of the modified normalization and the stress relieved weldments have proven very satisfactory in service.

**GEORGE C. EHEMANN, JR.:** I would like to ask a bit more about the stress relieving. Dr. Theisinger mentioned stress relieving at 1150 F, but there has been a great deal of stress relieving done at considerably lower temperatures. I noticed that one of the principal advantages he gains is in drawing the hardened metal. As far as the beneficial effects from stress relieving, where you are only interested in preventing those stresses which are tied up in the part from doing damage, is it really of any value? Are there often places where the locked-up stresses which come from the welding are addative to stresses which are imposed on the object? And can we gain much by stress relieving at lower temperatures, say six or seven hundred degrees?

**W. G. THEISINGER:** I am quite sure that partial stress relieving could be carried out at almost any temperature and time you may care to select. For example, it may be possible to actually stress relieve a welded structure at 800 F, if held for ten hours per inch of thickness. On the other hand, heating to 1600 F, should accomplish the same result after one-half hour per inch of plate thickness. I do not know that anyone has worked out a time-temperature relationship for stress relieving, but it is reasonable to expect that some such schedule would be effective. However, the low temperature-long time treatment would delay production considerably and a high temperature-short time cycle would cause distortion of the vessel. The lowest practical combination is the commonly used 1150 to 1200 F, for one hour per inch of thickness. The time required is short and the shape of the vessel is not affected.

Stress relieving is very definitely of value in the service life of the structure. Imposed stresses may be additive and failure can occur due to the lack of stress relieving. Stress relieving also improves the physical properties of the welded joint by increasing the ductility and making this property more uniform across the weld and the surrounding plate metal.

**WRAY DUDLEY:** I feel that Dr. Theisinger has presented the case for pre-heating in a very clear and convincing manner. However, I am somewhat surprised at the moderate range of temperature suggested. There is considerable maintenance and shop welding on sections less than 1 in. thick, and according to the author, the pre-heat temperature would be limited to 100 F. However, I believe the general practice would call for considerably higher values. We have frequently heated to 300-400 F without encountering any difficulty and have secured the desired results. In some sections of the southwest, air temperatures will reach 110 F in the summer time; the question then arises whether metal at this temperature would require further pre-heating.

**W. G. THEISINGER:** Unless the plates being welded are unusually heavy, 110 F atmospheric temperature should be sufficient for most weldments. In fact it has been stated that anything under 50 F is dangerous, and I believe the effect of relatively low temperatures is demonstrated by the greater number of welding difficulties during the winter than in summer where the range would normally be from 20 to 100 F, from winter to summer. I agree with Mr. Jennings that 100 degrees of pre-heat for each inch of plate thickness is a very rough figure, but the main purpose in stressing this value is to bring home the thought that heavy plate needs some assistance during welding. One of the easiest ways to do this is to introduce some temperature into the material. Pre-heating is not a "cure-all," but it is one of the first items that should be taken into account wherever heavy plate is involved. I see no reason why higher pre-heat temperatures would be harmful. In fact, they would be still greater insurance for a safe welding procedure. In general the lowest temperature to produce satisfactory results is used to avoid discomfort to the operator as much as possible. If possible, pre-heat higher than 100 F per inch of thickness, especially on the higher tensile strength materials.

**M. M. MACDONALD:** There is a question that occurs to me. How about annealing after you have made the weld? Nothing has been said about that, as far as I know. Our metallurgists for the last fifteen years have told me I might as well throw it away if I didn't anneal it after I got through with it in a good many cases. Is there any answer to that?

**W. G. THEISINGER:** Is your heat treatment after welding to be done at a temperature greater than 1150 F?

**M. M. MACDONALD:** In some cases, yes.

**W. G. THEISINGER:** A combination of rigid design and high tensile material such as Mr. Gibson described, would be benefited by an annealing treatment, where the temperature would be in the order of 1650 F.

I would prefer the stress relieving treatment of at least 1150 F, for a welded structure that would be subjected to any kind of high operating stresses. For example, high pressure boilers would be in a better condition to withstand operation after stress relieving than in the as-welded condition.

**J. H. COOPER:** Concerning Mr. Theisinger's paper, we believe that his data showing that an increase in the speed of welding produces higher hardness values in the material, without qualifying the circumstances concerning this test, may be very misleading. While he does not say so, we assume that the conditions of arc voltage, wire feed, welding current, etc., were kept constant, and the travel speed increased. This means that the welding conditions of deposition are changed, and this is something that would be seldom done in practice. Actually, what happened when the travel speed is increased, is to also increase the input energy and wire feed. It is quite possible under these actual conditions that the hardness values noted might be entirely different. We would be interested in receiving Mr. Theisinger's comments on this.

**W. G. THEISINGER:** Mr. Cooper has brought out a very significant point by calling our attention to the fact that in practice welding currents would be increased with increased welding speeds. For the purpose of the research problem, we attempted to show the effect of heat energy input which is derived by: amperage x volts ÷ welding speed.

By increasing the amperage and the speed the net result would be the same so that for any combination of amperage and welding speed we would develop the same heat input. Then any point on the above curves would produce similar hardness values along side the weld. As the welding speed is increased without any increase in amperage, the heat input falls off and the quenching rate is increased. This results in higher hardness values in the affected zones. If we had maintained the welding speeds but reduced the amperage in comparable steps instead, like results would have been obtained because the heat energy input per unit of weld was correspondingly reduced. During these experiments the arc voltage, welding current, etc., were held constant while the welding speeds were increased.

**F. C. SCHOEN:** Mr. Theisinger is to be commended on his excellent approach and treatment of a subject which deals with an increasingly valuable maintenance and construction aid. The analogy he has drawn between welding and casting in metal moulds gives me a much better understanding of why welds fail. This same story, if presented in pictorial form so that the welding operator might see why individual welds require individual treatment, should give him a higher percentage of satisfactory results. The author stresses the value of heat treatment of welds and the necessity of preheating to relieve cooling and shrinkage strains. This practice undoubtedly is very beneficial and useful where the job to be welded is in the shop or where facilities for preheating are available. However, in a large percentage of maintenance work, the welding unit is taken to the job, which may be in a shop with high temperatures or may be out in the field with zero temperatures. With these conditions of welding, an every day problem, is it possible that weld failure, which we blame on an incompetent operator, is not his fault?

When welding fire cracks in the furnace sheets of locomotive boilers, in the absence of heat treatment or preheating facilities, we have been using an air hammer with a blunt tool to thoroughly peen each bead of hot weld, thus obtaining very satisfactory results. This work, of course, is with mild steel plate, $\frac{3}{8}$ to $\frac{1}{2}$ in. thick.

Using the same method of peening when welding cracks which have developed in forged and cast pressure cylinders, with wall thicknesses of $1\frac{1}{2}$ to 2 in., has not been entirely satisfactory. As I understand Mr. Theisinger's paper, it is the lack of preheating which is at least partially responsible for the poor results obtained.

I would like to know, therefore, if in those cases where it is impractical to take heavy jobs into the shop, is it practical, in the field, to preheat with flame, the immediate section to be welded and has our practice of peening individual hot beads of welding any merit?

I have one final question which can best be asked by making a preliminary statement. We have been warned many times that welding high carbon or high alloy heat treated forgings is very dangerous, due to cracks developing from the weld, yet we have found it necessary to weld eroded gasket faces, cut and eroded valve seats and eroded packing surfaces in alloy forgings where the bursting stresses under load are quite high. This welding must be done with an electrode which will permit grinding or tooling of welded surfaces without the necessity of removing the forgings from pipe lines or pump beds if delays are to be avoided. In the last five years we have had no failures of these welded forgings due to cracks. I would appreciate Mr. Theisinger's opinion of why such results may be obtained consistently when no preheating or stress relieving is used?

**W. G. THEISINGER:** As Mr. Schoen points out there are many times when preheating cannot be employed and I agree with him that where failures occur under such conditions, the welding operator cannot be at fault. In such cases, some means other than preheating must be devised to aid this welding problem. For example, it might help to deposit the beads against the sides of the plates in the groove and finally join them together rather than attempt to weave the deposited metal completely across the joint in one pass. Also a number of beads in one spot is better than a series of long, thin beads which have time to cool before the next one is deposited. In other words, try to maintain some heat in the area by welding, if exterior heating is not possible.

The question of peening the weld has often been discussed and if the hammering is done on a hot weld, this operation is helpful, but work done on a cold weld is of doubtful value. In the welding of heavy sections, I believe that preheating is mandatory, and a job in the field should be preheated by flame in the vicinity of the repair. To obtain any value from peening, it should be done immediately after each length of rod is deposited. If cracks still occur after this hot working, the length of deposited bead should be limited to six inches to be followed at once by peening.

I believe that Mr. Schoen is doing an excellent job welding high carbon or alloy forgings without difficulty. If I understand the problem correctly, it is more a case of metal surfacing rather than the welding of two pieces together. If such is the case, the contraction stress is over a plane rather than in a confined area between two rigid pieces. In any event, Mr. Schoen has solved a very difficult problem.

# Technical Program of the

# AMERICAN IRON AND STEEL INSTITUTE

## Surveys Production Achievements

*Reviewing the problems of wartime production and expansion, leading operators of the industry presented a number of very interesting papers at the technical session of the American Iron and Steel Institute, held in New York, May 27th. Dealing for the most part with the methods by which the record productions were made, emphasis was also placed on the conservation of the critical alloying materials. To date, most of the production increases have come from existing equipment, with little help from the new construction. For their benefit to the general production effort, the following abstracts of some of these papers are presented.*

## Expansion Program of The Steel Industry

**By J. A. KINNEY**

**Assistant to Vice President**

**Bethlehem Steel Company, Bethlehem, Penna.**

▲ IN order to evaluate the present wartime expansion program of the industry in terms of normal growth, three periods of industry expansion will be reviewed.

The first period includes the elapsed time between January 1, 1920 and January 1, 1940. It is a twenty-year peacetime period, during which growth of the industry may be taken as the measure of expansion necessary to keep pace with normal market development.

The second period covers the first two full calendar years of hostilities in Europe, 1940 and 1941. During this time expansion of the industry was mostly the result of individual company effort, without the benefit of national planning or public financing.

The third period begins with January 1, 1942 and extends to completion of the steel expansion program now under way, which by all present appearances will

**TABLE II**

**W. P. B. Steel Expansion Program**

**Increases in Electric Furnace Capacity**

**(Net tons Annually)**

| Company | Location | Capacity |
|---|---|---|
| American Rolling Mill Co. | Middletown, Ohio | 43,000 |
| Andrews Steel Co. | Newport, Ky. | 195,000 |
| Babcock & Wilcox Tube Co. | Beaver Falls, Pa. | 48,000 |
| Byers Co., A. M. | Ambridge, Pa. | 72,000 |
| Carnegie-Illinois Steel Corp. | Duquesne, Pa. | 165,000 |
| Copperweld Steel Co | Warren, Ohio | 324,000 |
| Jessop Steel Co. | Washington, Pa. | 46,000 |
| Isaacson Iron Works | Seattle, Wash. | 75,000 |
| Oregon Electric Steel Rolling Mills | Portland, Ore. | 60,000 |
| Pacific States Steel Corp. | Niles, Cal. | 54,000 |
| Republic Steel Corp. | Canton, Ohio | 221,000 |
| Republic Steel Corp. | South Chicago, Ill. | 918,000 |
| Rotary Electric Steel Co. | Detroit, Mich. | 80,000 |
| Youngstown Sheet & Tube Co. | Indiana Harbor, Ind. | 120,000 |
| Miscellaneous additions not in projects | | 146,000 |
| Total increase in W. P. B. program | | 2,567,000 |
| Total war expansion since 1-1-40 | | 4,427,000 |
| Annual capacity January 1, 1938 | | 1,500,000 |
| Annual capacity January 1, 1939 | | 1,730,000 |
| Annual capacity January 1, 1940 | | 1,888,000 |
| Annual capacity January 1, 1941 | | 2,590,000 |
| Annual capacity January 1, 1942 | | 3,741,000 |
| Annual capacity January 1, 1943 | | 4,559,000 |
| Annual capacity on completion of program | | 6,315,000 |

## TABLE I

### W. P. B. Steel Expansion Program

### Increases in Open Hearth Capacity (Net tons Annually)

| Company | Location | New furnaces | Enlargements | Hot metal | Total |
|---|---|---|---|---|---|
| American Locomotive Co. | Latrobe, Pa. | | 20,000 | | 20,000 |
| American Locomotive Co. | Chicago Hts., Ill. | | 100,000 | | 100,000 |
| American Rolling Mill Co. | | | | | |
| Sheffield Steel Corp. | Kansas City, Mo. | | 72,000 | | 72,000 |
| Sheffield Steel Corp. | Houston, Texas | 525,000 | | | 525,000 |
| Barium Stainless Steel Corp. | Canton, Ohio | 30,000 | | | 30,000 |
| Bethlehem Steel Company | Bethlehem, Pa. | 300,000 | | | 300,000 |
| Bethlehem Steel Company | San Francisco, Cal. | 55,000 | | | 55,000 |
| Bethlehem Steel Company | Seattle, Wash. | 45,000 | | | 45,000 |
| Byers Co., A. M. | Ambridge, Pa. | 36,000 | | | 36,000 |
| Continental Steel Corp. | Kokomo, Ind. | | 30,000 | | 30,000 |
| Crucible Steel Co. of America | Pittsburgh, Pa. | 36,000 | | | 36,000 |
| Granite City Steel Co. | Granite City, Ill. | 300,000 | | | 300,000 |
| Great Lakes Steel Corp. | Detroit, Mich. | 25,000 | | | 25,000 |
| Jones & Laughlin Steel Corp. | Pittsburgh, Pa. | | 70,000 | | 70,000 |
| Kaiser Co., Henry J. | Fontana, Cal. | 675,000 | | | 675,000 |
| Laclede Steel Co. | Alton, Ill. | | 40,000 | | 40,000 |
| Lukens Steel Co. | Coatesville, Pa. | 160,000 | | | 160,000 |
| Phoenix Iron Co. | Phoenixville, Pa. | 50,000 | | | 50,000 |
| Pittsburgh Steel Co. | Monessen, Pa. | | 67,000 | 181,000 | 248,000 |
| Republic Steel Corp. | Cleveland, Ohio | | | 240,000 | 240,000 |
| Republic Steel Corp. | Youngstown, Ohio | | | 220,000 | 220,000 |
| Republic Steel Corp. | Gadsden, Ala. | | | 120,000 | 120,000 |
| U. S. Steel Corp. | | | | | |
| American Steel & Wire Co. | Duluth, Minn. | | | 60,000 | 60,000 |
| American Steel & Wire Co. | Donora, Pa. | | 88,000 | | 88,000 |
| Carnegie-Illinois Steel Corp. | Braddock, Pa. | | 25,000 | | 25,000 |
| Carnegie-Illinois Steel Corp. | Gary, Ind. | 150,000 | | 150,000 | 300,000 |
| Carnegie-Illinois Steel Corp. | Homestead, Pa. | 1,740,000 | | | 1,740,000 |
| Carnegie-Illinois Steel Corp. | Youngstown, Ohio | | 80,000 | | 80,000 |
| Columbia Steel Co. | Geneva, Utah | 1,300,000 | | | 1,300,000 |
| Tennessee Coal, Iron & Railroad Co. | Birmingham, Ala. | | | 120,000 | 120,000 |
| Youngstown Sheet & Tube Co. | East Chicago, Ind. | | 125,000 | | 125,000 |
| Total increase in W. P. B. program | | 5,427,000 | 717,000 | 1,091,000 | 7,235,000 |
| Per cent of total W. P. B. program | | 75% | 10% | 15% | 100% |

| | |
|---|---|
| Increase in W. P. B. program | 7,235,000 |
| Total war expansion since 1-1-40 | 10,766,000 |
| Annual capacity 1-1-38 | 71,472,000 |
| Annual capacity 1-1-39 | 72,960,000 |
| Annual capacity 1-1-40 | 73,722,000 |
| Annual capacity 1-1-41 | 74,566,000 |
| Annual capacity 1-1-42 | 78,107,000 |
| Annual capacity 1-1-43 | 79,181,000 |
| Annual capacity end of program | 84,788,000 |

Conversions to increased alloy steel production will reduce effective capacity by 500,000 to 600,000 tons.

extend beyond the end of this year. During this period, government and industry, through a series of surveys, and under the guidance of the War Production Board, agreed upon and put into execution a steel expansion program, financed partly through government agencies and partly through private enterprise.

January 1, 1942 has been selected as marking the dividing line between strictly private expansion and W. P. B. expansion. Although there is some overlap, this date comes close to dividing the two programs on a time basis.

The W. P. B. expansion program is notable in respect that instead of the usual balancing and rounding out of capacities, it represents a carefully balanced program of expansion, beginning with the mining of ore and carrying through to and including the necessary steel finishing facilities, in some cases including fully integrated steel plants. The industry committee, working with W. P. B., laid the foundation for this program by starting with the best combined information obtainable on product increases needed for the war effort, and building back through the various facility expansions necessary to produce these products. Part of this program, but by no means all of it, is being financed by government agencies, particularly the Navy and the Defense Plant Corporation. Part of it represents private expansion under way at the time the W. P. B. program was inaugurated, which has been included in the W. P. B. program.

The appendix of this paper contains a detailed listing by companies of the major additional facilities, with annual capacities, included in the W. P. B. steel expansion program (see accompanying tables).

The annual requirement of Lake ore at the end of the expansion program is estimated at 109,101,000 net tons, of which 3,751,000 net tons will go to Canada and

## TABLE III

### W. P. B. Steel Expansion Program

### Increases in Blast Furnace Capacity — Pig Iron and Ferroalloys (Net tons Annually)

| Company | Location | New furnaces | Rehabilitated furnaces | Rebuilt and enlarged furnaces | Use of sinter | Total capacity increase |
|---|---|---|---|---|---|---|
| American Rolling Mill Co. | Ashland, Ky. | 432,000 | | | | 432,000 |
| Sheffield Steel Corp. | Houston, Tex. | 274,000 | | | | 274,000 |
| Bethlehem Steel Co. | Bethlehem, Pa. | 432,000 | | | | 432,000 |
| Bethlehem Steel Co. | Johnstown, Pa. | | | 54,000 | | 54,000 |
| Bethlehem Steel Co. | Lackawanna, N. Y. | 432,000 | | 192,000 | | 624,000 |
| Colorado Fuel & Iron Co. | Pueblo, Colo. | 227,000 | | | | 227,000 |
| Cumberland Iron Co. | Cumberland, Tenn. | | 32,000 | | | 32,000 |
| Inland Steel Co. | Indiana Harbor, Ind. | 1,260,000 | | | 73,000 | 1,333,000 |
| Interlake Iron Corp. | Chicago, Ill. | | | 100,000 | 33,000 | 133,000 |
| Interlake Iron Corp. | Toledo, Ohio | | | | 32,000 | 32,000 |
| Jones & Laughlin Steel Corp. | Aliquippa, Pa. | | | 114,000 | 402,000 | 516,000 |
| Kaiser Co., Henry J. | Fontana, Cal. | 432,000 | | | | 432,000 |
| Koppers-United Co. | Granite City, Ill. | | 225,000 | | | 225,000 |
| Lone Star Steel Co. | Daingerfield, Tex. | 432,000 | | | | 432,000 |
| Pittsburgh Coke and Iron Co. | Neville Island, Pa. | | | 40,000 | 40,000 | 80,000 |
| Pittsburgh Ferro Manganese Co. | Chester, Pa. | | 144,000 | | | 144,000 |
| Pittsburgh Steel Co. | Monessen, Pa. | 432,000 | | | | 432,000 |
| Republic Steel Corp. | Gadsden, Ala. | 280,000 | | | | 280,000 |
| Republic Steel Corp. | Cleveland, Ohio | 450,000 | | | | 450,000 |
| Republic Steel Corp. | Youngstown, Ohio | 392,000 | | | | 392,000 |
| Republic Steel Corp. | Chicago, Ill. | 450,000 | | | | 450,000 |
| United States Steel Corp. | | | | | | |
| American Steel & Wire Co. | Cleveland, Ohio | | | 40,000 | | 40,000 |
| American Steel & Wire Co. | Duluth, Minn. | | 266,000 | | | 266,000 |
| Carnegie-Illinois Steel Corp. | Braddock, Pa. | 860,000 | | | | 860,000 |
| Carnegie-Illinois Steel Corp. | Clairton, Pa. | | | 100,000 | | 100,000 |
| Carnegie-Illinois Steel Corp. | Rankin, Pa. | | | 131,000 | | 131,000 |
| Carnegie-Illinois Steel Corp. | Mingo Junction, Ohio | | | 32,000 | | 32,000 |
| Carnegie-Illinois Steel Corp. | Gary, Ind. | | | 144,000 | | 144,000 |
| Columbia Steel Co. | Provo, Utah | | 300,000 | | | 300,000 |
| Columbia Steel Co. | Geneva, Utah | 1,149,000 | | | | 1,149,000 |
| National Tube Co. | Lorain, Ohio | | | 144,000 | | 144,000 |
| Tennessee Coal, Iron & Railroad Co. | Birmingham, Ala. | 319,000 | | | | 319,000 |
| Wheeling Steel Corp. | Steubenville, Ohio | | | | 70,000 | 70,000 |
| Youngstown Sheet & Tube Co. | Campbell, Ohio | | | 108,000 | 139,000 | 247,000 |
| Youngstown Sheet & Tube Co. | Indiana Harbor, Ind. | | | | 62,000 | 62,000 |
| Total increase in W. P. B. program | | 8,253,000 | 967,000 | 1,199,000 | 851,000 | 11,270,000 |
| Per cent of total W. P. B. program | | 73.2% | 8.6% | 10.6% | 7.6% | 100.0% |

| | |
|---|---|
| Increase in W. P. B. program | 11,270,000 |
| Annual capacity 1-1-40 | 55,724,000 |
| Total war expansion since 1-1-40 | 15,563,000 |
| Annual capacity 1-1-38 | 56,782,000 |

| | |
|---|---|
| Annual capacity 1-1-39 | 56,326,000 |
| Annual capacity 1-1-41 | 57,610,000 |
| Annual capacity 1-1-42 | 60,394,000 |
| Annual capacity 1-1-43 | 63,934,000 |
| Annual capacity end of program | 71,287,000 |

105,350,000 net tons to the U. S. A. Shipping capacity at the end of the program will be:

| | *Net tons* |
|---|---|
| Total by water | 107,299,360 |
| Total by rail | 2,460,640 |
| Total shipping capacity | 109,760,000 |
| By water to Canada | 3,751,000 |
| Total to U. S. A. | 106,009,000 |

A check of the approximate metallics balance of the industry operating at capacity after completion of the steel expansion program is of interest:

| | *Net tons* |
|---|---|
| *Blast furnace production* | |
| Pig iron and ferroalloys capacity, annually | 71,287,000 |
| Less merchant pig iron and ferroalloys | 10,000,000 |
| Pig iron available for steelmaking | 61,287,000 |
| *Steelmaking production* | |
| Open hearth capacity annually | 84,788,000 |
| Bessemer capacity annually | 6,553,000 |
| Electric furnace capacity annually | 6,315,000 |
| Total ingot capacity | 97,656,000 |
| Recirculating scrap — 27.75 per cent of ingots | 27,100,000 |
| Electric furnace charge | 6,946,000 |
| Recirculating scrap available for open hearth | 20,154,000 |
| Pig iron available for steelmaking | 61,287,000 |
| Bessemer charge | 7,210,000 |

## TABLE IV

### W. P. B. Steel Expansion Program

### Increases in By-Product Coke Capacity

### (Net tons Annually)

| Company | Location | Capacity |
|---|---|---|
| Bethlehem Steel Co. | Lackawanna, N. Y. | 438,000 |
| Bethlehem Steel Co. | Steelton, Pa. | 365,000 |
| Carnegie-Illinois Steel Corp. | Gary, Ind. | 350,000 |
| Columbia Steel Co. | Geneva, Utah | 1,006,000 |
| Inland Steel Co. | Indiana Harbor, Ind. | 798,000 |
| Interlake Iron Corp. | Erie, Pa. | 210,000 |
| Kaiser Co., Henry J. | Fontana, Cal. | 340,000 |
| Koppers-United | Granite City, Ill. | 305,000 |
| Lone Star Steel Co. | Daingerfield, Texas | 375,000 |
| Pittsburgh Steel Co. | Monessen, Pa. | 460,000 |
| Republic Steel Corp. | Chicago, Ill. | 465,000 |
| Republic Steel Corp. | Cleveland, Ohio | 465,000 |
| Republic Steel Corp. | Gadsden, Ala. | 400,000 |
| Republic Steel Corp. | Warren, Ohio | 375,000 |
| Sheffield Steel Corp. | Houston, Texas | 245,000 |
| Tennessee Coal, Iron & Railroad Co. | Birmingham, Ala. | 375,000 |
| Weirton Steel Co. | Weirton, W. Va. | 245,000 |
| Total increase in W. P. B. program | | 7,217,000 |
| Total war expansion since 1-1-40 | | 8,978,000 |
| Annual capacity January 1, 1938 | | 44,791,000 |
| Annual capacity January 1, 1939 | | 46,171,000 |
| Annual capacity January 1, 1940 | | 48,384,000 |
| Annual capacity January 1, 1941 | | 48,794,000 |
| Annual capacity January 1, 1942 | | 50,292,000 |
| Annual capacity January 1, 1943 | | 51,708,000 |
| Annual capacity on completion of program | | 57,362,000 |

| | |
|---|---|
| Pig iron available for open hearth | 54,077,000 |
| Open hearth charge | 95,387,000 |
| Pig iron — 56.7 per cent of charge | 54,077,000 |
| Recirculating scrap | 20,154,000 |
| Metallics in ore | 4,769,000 |
| Purchased scrap (by difference) | 16,380,000 |

The February 1943 issue of Steel Facts, a publication of the American Iron and Steel Institute, gave the expenditure of both private and government funds in expansion of the steel industry since the beginning of the war, from which the figures quoted herein are taken.

Steel companies have invested nearly $1,205,000,000 of their own funds to increase capacity and improve their equipment since 1938. Approximately $432,000,000 was spent during the years 1938 through 1940 when hostilities were beginning. From 1941 through 1943, the industry has spent or is preparing to spend $773,000,000.

The industry's own expenditures for this purpose were augmented, beginning in 1941, with appropriations from government funds to install certain new equipment wanted for war work. Approximately $900,000,000 in government money has been spent or will be spent for that purpose in the three years 1941 through 1943. The combined total of government and private funds used for expanding the steel industry from 1941 forward to completion of the present program, therefore, will be approximately $1,673,000,000.

## TABLE V

### W. P. B. Steel Expansion Program

### Anticipated Ore Sources for Expanded Facilities

### (W. P. B. Estimate March 15, 1943)

| Source of ore | Annual capacity, net tons | | | |
|---|---|---|---|---|
| | January 1, 1942 | January 1, 1943 | End of program | Program increase |
| Texas and Missouri | 22,000 | 56,000 | 1,500,000 | 1,478,000 |
| Foreign | 2,312,000 | 530,000 | | —2,312,000 |
| Eastern | 3,696,000 | 4,600,000 | 7,865,000 | 4,169,000 |
| Western | 1,568,000 | 2,624,000 | 5,200,000 | 3,632,000 |
| Southern | 9,408,000 | 10,416,000 | 12,265,000 | 2,857,000 |
| Lake | 101,577,000 | 104,621,000 | 112,109,000 | 10,532,000 |
| Total | 118,583,000 | 122,847,000 | 138,939,000 | 20,356,000 |

*Consumption of Lake Ore at Completion of Program*

| | |
|---|---|
| Estimated annual consumption U. S. A. | 105,350,000 |
| Estimated annual consumption Canada | 3,751,000 |
| Estimated annual consumption — Total | 109,101,000 |

*Transportation of Lake Ore at Completion of Program*

| | |
|---|---|
| Total by water | 107,299,360 |
| Total by rail | 2,460,640 |
| Total shipping capacity | 109,760,000 |
| By water to Canada | 3,751,000 |
| Total to U. S. A. | 106,009,000 |

## TABLE VI

### W. P. B. Steel Expansion Program

### Increases in Ore Sintering Capacity

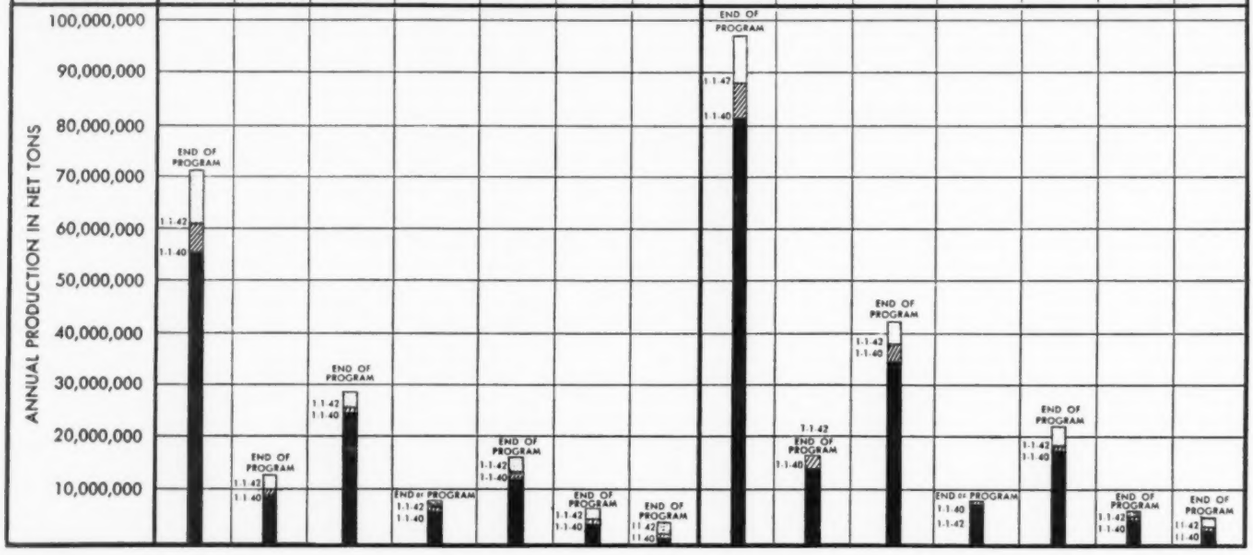
### (Net tons Annually)

| Company | Location | Capacity |
|---|---|---|
| Alan Wood Steel Co. | Dover, N. J. | 300,000 |
| American Rolling Mill Co. | Hamilton, Ohio | 540,000 |
| Bethlehem Steel Co. | Bethlehem, Pa. | 360,000 |
| Colorado Fuel & Iron Corp. | Pueblo, Colo. | 720,000 |
| Columbia Steel Co. | Ironton, Utah | 300,000 |
| Columbia Steel Co. | Geneva, Utah | 800,000 |
| Inland Steel Co. | Indiana Harbor, Ind. | 432,000 |
| Interlake Iron Corp. | Chicago, Ill. | 600,000 |
| Interlake Iron Corp. | Toledo, Ohio | 600,000 |
| Jones & Laughlin Steel Corp. | Pittsburgh, Pa. | 558,000 |
| Jones & Laughlin Steel Corp. | Benson, N. Y. | 1,120,000 |
| Kaiser Co., Henry J. | Fontana, Cal. | 467,000 |
| Pittsburgh Coke & Iron Co. | Neville Island, Pa. | 45,000 |
| Republic Steel Corp. | Spaulding, Ala. | 350,000 |
| Republic Steel Corp. | Port Henry, N. Y. | 765,000 |
| Republic Steel Corp. | Cleveland, Ohio | 360,000 |
| Republic Steel Corp. | Warren, Ohio | 382,000 |
| Republic Steel Corp. | Youngstown, Ohio | 392,000 |
| Republic Steel Corp. | Chicago, Ill. | 300,000 |
| Wheeling Steel Corp. | Steubenville, Ohio | 360,000 |
| Youngstown Sheet & Tube Co. | Campbell, Ohio | 720,000 |
| Youngstown Sheet & Tube Co. | S. Chicago, Ill. | 300,000 |
| Total increase in W. P. B. program | | 10,771,000 |
| Capacity in effect January 1, 1942 | | 16,371,000 |
| Capacity in effect at end of program | | 27,142,000 |
| Increase over January 1, 1942 in per cent | | 66% |

## STEEL EXPANSION PROGRAM

GEOGRAPHICAL DISTRIBUTION OF PIG IRON AND INGOT CAPACITIES — NET TONS ANNUALLY

| DATE | PIG IRON | | | | | | | TOTAL INGOTS | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TOTAL INDUSTRY | EASTERN DISTRICT | PITTSBURGH YOUNGS-TOWN DISTRICT | CLEVELAND DETROIT DISTRICT | CHICAGO DISTRICT | SOUTHERN DISTRICT | WESTERN DISTRICT | TOTAL INDUSTRY | EASTERN DISTRICT | PITTSBURGH YOUNGS-TOWN DISTRICT | CLEVELAND DETROIT DISTRICT | CHICAGO DISTRICT | SOUTHERN DISTRICT | WESTERN DISTRICT |
| JANUARY 1, 1940 | 55,724,000 | 9,025,000 | 25,054,000 | 5,550,000 | 11,625,000 | 3,665,000 | 805,000 | 81,619,000 | 14,153,000 | 35,180,000 | 7,887,000 | 17,817,000 | 4,377,000 | 2,205,000 |
| JANUARY 1, 1942 | 60,394,000 | 10,040,000 | 25,900,000 | 6,010,000 | 12,917,000 | 4,555,000 | 972,000 | 88,570,000 | 16,087,000 | 38,435,000 | 7,826,000 | 18,981,000 | 4,868,000 | 2,373,000 |
| COMPLETION OF PROGRAM | 71,287,000 | 11,956,000 | 28,681,000 | 6,575,000 | 15,138,000 | 5,922,000 | 3,015,000 | 97,656,000 | 16,330,000 | 41,727,000 | 8,022,000 | 21,213,000 | 5,714,000 | 4,650,000 |
| EXPANSION 1-1-40 TO 1-1-42 | 4,670,000 | 1,015,000 | 846,000 | 460,000 | 1,292,000 | 890,000 | 167,000 | 6,951,000 | 1,934,000 | 3,255,000 | 61,000 | 1,164,000 | 491,000 | 168,000 |
| EXPANSION 1-1-42 TO END OF PROGRAM | 10,893,000 | 1,916,000 | 2,781,000 | 565,000 | 2,221,000 | 1,367,000 | 2,043,000 | 9,086,000 | 357,000 | 3,292,000 | 196,000 | 2,232,000 | 846,000 | 2,277,000 |
| TOTAL WAR EXPANSION | 15,563,000 | 2,931,000 | 3,627,000 | 1,025,000 | 3,513,000 | 2,257,000 | 2,210,000 | 16,037,000 | 2,177,000 | 6,547,000 | 135,000 | 3,396,000 | 1,337,000 | 2,445,000 |
| INCREASE OVER JAN. 1, 1940 | 27.9% | 32.5% | 14.5% | 18.5% | 30.2% | 61.6% | 274.5% | 19.6% | 15.3% | 18.6% | 1.7% | 13.4% | 30.5% | 110.9% |




## TABLE VII

### W. P. B. Steel Expansion Program

### Additional Rolling Mills

| Company | Location | Blooming mills | Plate mills | Structural mills | Bar mills |
|---|---|---|---|---|---|
| Copperweld Steel Co. | Warren, Ohio | | | | 24″—21″ bar mill |
| Granite City Steel Co. | Granite City | | Revamp 90″ plate mill | | |
| Jessop Steel Co. | Washington, Pa. | | | | 18″ bar mill |
| Kaiser Co., Henry J. | Fontana, Cal. | 42″—2-high reversing 36″ breakdown mill | 110″ plate mill—1-roughing and finishing stand | 28″ structural mill | 18″—14″ merchant mill |
| Lukens Steel Co. | Coatesville, Pa. | | 120″—4-high reversing as finisher for present 112″ | | |
| Oregon Electric Steel Rolling Mills | | | | | 20″—12″—9″ bar-structural mill |
| Republic Steel Corp. | Chicago, Ill. | 44″—2-high reversing 36″—secondary bloomer | | | 32″ bar mill |
| Sheffield Steel Corp. | Houston, Tex. | 36″—2-high reversing | 110″—3-high reversing | | |
| United States Steel Corp. Carnegie-Illinois Steel Corp. | Homestead, Pa. | 44″—2-high reversing | 160″—4-high reversing Revamp 100″ plate mill | | |
| Columbia Steel Co. | Geneva, Utah | 44″—2-high reversing 28″—2-high reversing | 132″ six stand 4-high continuous plate mill | 24″ structural mill | |

# Increased Blast Furnace Capacity and How Accomplished

**By GEORGE T. WILLIAMS**

Superintendent, Blast Furnaces and Coke Plant, Indiana Harbor Works

and

**B. M. STUBBLEFIELD**

Superintendent, Blast Furnaces and Coke Plant, Campbell Works, The Youngstown Sheet and Tube Company

▲ IN reporting how blast furnace engineers and operators have produced greater tonnages of iron, a survey was made, covering 78 plants operating 225 blast furnaces.

First item in the production story is the new construction — 23 furnaces ranging 20-27 ft in hearth diameter, built with private and government financing, and totaling about 9,000,000 net tons per year capacity.

Seven projects were reported of replacing an old furnace by a new and larger one, thus adding 1,000,000 tons to our annual iron capacity. Some plants are increasing capacity by enlarging hearth and bosh without changing the shell.

In all these fields, record time have been made. The records show one new furnace put into blast on a new site in 119 days. Replacing an old furnace with a new one, normally a five month job, has been accomplished in as little as 83 days. One plant saved 10 days by dynamiting the old furnace. Another saved 67 days by building the new shell to one side of the site and moving it into place. Still another plant enlarged an old furnace and completely relined it in 21 days — a job normally estimated at 75 days. Normal relining, including hearth renewal but without enlarging, has been estimated to require about 60 days from blow-out to blow-in. Many reports show 40 days or less, running down to 28½ days.

Time-saving methods contributing to these records include draining of the salamander iron; pre-cutting the hearth blocks outside the furnace; installing the new lining simultaneously in two stages, from mantle to top and from bottom to mantle; and intensive round-the-clock work to repair auxiliaries. Tapping the salamander will save about 14 days time. Pre-cutting hearth blocks is said to save two days, and installing the brick work in two stages will save seven days.

Relining above the mantle without removal of the salamander or renewal of the bosh, normally a 30 day job, is now done in 16-21 days.

There were 45 relinings of all sorts in 1942 and it is estimated there will be 75 in 1943. Nearly every plant reports greater tonnages on linings, 2,000,000 tons being quite regular with some furnaces at about 3,000,000 tons. The increased tonnage is attributed to improved refractories, better preparation of charged materials, and better furnace handling.

Operators generally believe in the advantage of sinter to a certain extent. They feel that the advantage begins with the use of 10-20 per cent in the charge, increases up to 35-45 per cent sinter, and then does not increase so much with further increases in sinter. A conservative statement is that from every 10 tons of sinter charged per day, there will be produced one additional ton per day.

New sintering capacity, added and under construction, is estimated at 9,800,000 tons per year, 7,000,000 tons for magnetites. This, added to the existing 11,000,000 ton per year capacity, will give an overall average of 16 per cent of the national furnace burden, and will result in about 1,000,000 additional tons of iron per year.

The practice of screening ore and charging the different sizes separately has shown excellent results and is being extended.

Fourteen blast condition units have been installed on 22 furnaces, being variously used on the suction or discharge side of the blower, and operating with refrigeration or chemical absorption. Some are equipped to add moisture in order to obtain uniformity. Little data is reported as to the advantages of this auxiliary.

Changes at coal mines and coke plants are reported, all tending to increase coke production and maintain or improve quality. Coal washing, the use of more low volatile coal, increasing the bulk density of the coal charge, etc., are mentioned.

# Increase in Open Hearth Production and How Achieved

**By A. P. MILLER**

Assstant General Superintendent, Inland Steel Company, Chicago

▲ THE increase in open hearth production is attributed to three main sources:

1. The increase resulting from additional furnace capacity which has become available.

2. The increase resulting from operating furnaces a greater percentage of the available time.

3. The increase resulting from greater tons per operating day in existing furnaces.

The increase in actual capacity has been accomplished by building new furnaces and by enlarging existing furnaces. As indicated by the accompanying table, since 1938 there has been an increase in the size of open hearth furnaces, but a decrease in the total number of furnaces, occurring principally in the small and very large sizes. In some cases, hearth area has been increased by moving chill boxes back as far as possible, by reducing size and increasing the elevation of the chill boxes, or by widen-

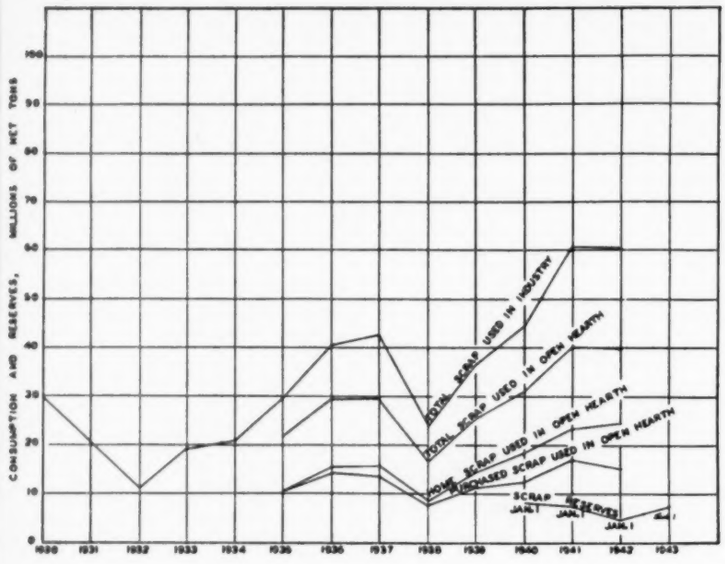



**Chart showing annual scrap consumption and the scrap reserves in the steel industry.**

## TABLE I

## Comparison of Open Hearth Furnace Sizes for the Years 1938 and 1942

| Rated capacity per heat, net tons | July 1, 1938 | | December 31, 1942 | |
|---|---|---|---|---|
| | Number | Per cent | Number | Per cent |
| Up to 24 | 20 | 2.0 | 16 | 1.7 |
| 25—39 | 28 | 2.8 | 29 | 3.0 |
| 40—54 | 71 | 7.1 | 52 | 5.4 |
| 55—69 | 89 | 8.9 | 63 | 6.5 |
| 70—84 | 103 | 10.4 | 96 | 9.9 |
| 85—99 | 49 | 4.9 | 46 | 4.8 |
| 100—114 | 221 | 22.2 | 194 | 20.0 |
| 115—129 | 96 | 9.7 | 103 | 10.6 |
| 130—144 | 128 | 12.9 | 152 | 15.7 |
| 145—159 | 41 | 4.1 | 27 | 2.8 |
| 160—174 | 99 | 10.0 | 115 | 11.9 |
| 175—189 | 8 | 0.8 | 17 | 1.8 |
| 190—204 | 9 | 0.9 | 40 | 4.1 |
| 205—219 | 0 | .... | 0 | .... |
| 220—234 | 12 | 1.2 | 12 | 1.2 |
| 235 and over | 21 | 2.1 | 6 | 0.6 |
| Total | 995 | 100.0 | 968 | 100.0 |
| Average furnace size | 111.7 net tons | | 115.6 net tons | |

ing the hearth toward the pit. Bath depth has been increased by raising the foreplate level, or by lowering the bottom through decreasing its thickness.

The percentage of time which furnaces are operated has been stepped up to figures of 90-95 per cent. This is largely due to improved maintenance, proper planning and scheduling of rebuilds, wider use of basic refractories throughout furnace construction, etc. In general, roof life has decreased because of the hard driving to which the furnace is subjected.

Basic brick has in some cases been used for the entire construction above floor level with the exception of the roof, front wall arches and wing panels. Bottom construction has been revolutionized through the cold rammed refractory material.

Rate of production, or tons per furnace day, has generally increased. Increased hot metal charges have, in many cases, stepped up this figure, although in some cases, the difficulties arising from higher hot metal charges more than nullify the gain. In several plants under consideration, optimum production is reached with between 60 and 64 per cent hot metal in the charge.

Charging sequences have been changed to obtain greatest benefit from the higher metal charges. Raw materials are delivered to the floor in proper sequence for direct charging into the furnace. The number and size of ladles had to be increased to accommodate the increased production, and pouring stands required rebuilding in some cases. Larger charging pans may be used to balance the lighter character of purchased scrap. An adequate supply of charging cars and pans of adequate capacity are essential.

Scrap should be properly distributed in the furnace, with light scrap on the bottom, butts evenly distributed, no turnings or borings on top of the charge, and no bulky charges in the door before the slag notch on flush heats. The blending of heavy and light scrap, keeping the bulk and exposed surface uniform, is advantageous.

Without flush practice, optimum production with increased iron charges is obtained with 3 per cent of ore in the charge. For each type of ore charge, optimum production results with a certain percentage of iron in the charge. When necessary to operate with metal charges above the optimum, the use of sinter to augment the ore is beneficial.

Other factors contributing to higher rates of production include blowing out checkerwork regularly, sealing and insulation of the furnace, use of forced air and induced draft, furnace instruments, slag control, rapid methods of chemical analysis, diesel motive power, incentive systems for operation and for repair.

# Wartime Production of Constructional Steels in the Basic Electric Furnace

**By H. W. McQUAID**

Assistant Chief Metallurgist,
Republic Steel Corporation, Cleveland, Ohio

▲ The basic electric furnace has certain definite advantages over other steel producing units. These advantages may be summarized as follows:

A. Steel can be produced rapidly under non-oxidizing equilibrium conditions.

B. Cleaner and more uniform steels can be made commercially with higher yields and lower rejections.

C. Poorer raw materials can be converted into higher quality products.

D. Closer analysis limits can be maintained.

These major advantages result in other advantages which are also of considerable importance. For example, it is possible to recover valuable oxidized elements, such as chromium, manganese, vanadium and tungsten, with much less loss than in even the best open hearth practice. At the present time this might even be listed as a major advantage. Control of grain size, abnormality and hardenability are also simplified greatly in the electric furnace. Improved homogeneity is possible; most ladle additions can be avoided and increased temperatures can be more accurately controlled. Because the tapping slag is low in oxide and strongly basic, the metal will maintain its analysis throughout the pouring of even the largest heats.

The basic electric furnace in the larger sizes can produce the highest grade steel in quantities comparing favorably with the best basic open hearths. In one plant, basic electric furnaces charging 60 tons of cold scrap are producing finished aircraft and bearing quality steel at an average monthly rate of 10 tons per hour. The average for the industry in this size furnace is below this figure, being probably not over 9 tons per hour.

As a matter of fact, we have not yet really begun to utilize the large basic electric furnace for the purpose for which it is most ideally fitted, i.e., as a refining medium. When used primarily for converting highly oxidized liquid steel into steel of excellent quality the most economical results can be obtained by combining the operation of basic electric furnace with the least expensive method of converting solid scrap to liquid metal. That method today is a modern cupola, especially designed for the purpose, which will convert the scrap to a liquid. The product will be approximately 3.5 per cent carbon; the phosphorus will be over 0.1 per cent and the sulphur over 0.08 per cent.

The suggestion that cupola iron be charged in the basic electric furnace, with ore to oxidize the carbon and phosphorus, has been met with skepticism by many who still insist that it can't be done. However, charging cold ore in one mass on the bottom of an electric furnace, then charging hot metal with 3.5 per cent carbon and 0.125 per cent phosphorus (which has been treated to reduce the sulphur), is being done. The carbon and phosphorus are eliminated at what seems an impossible rate, and without undue foaming or wild action in the furnace. With a properly engineered plant, we should be able to produce high grade electric furnace steel from 60 ton charges at approximately 20 tons per hour, with greatly reduced power and electrode cost.

If we wish to obtain the maximum production from the electric furnace we can turn to the bessemer converter, or to the basic open hearth, as an intermediate step between the cupola or the blast furnace and the electric furnace. The converter-electric furnace combination is being used to good advantage in Russian, Belgian and German practice. To aid us in successfully applying the practice here we have today the additional advantages of larger furnaces. Moreover, we are now aware of the necessity of a high degree of oxidation as a preliminary step in making the highest grade steel, and are also well along in developing methods which are extremely efficient in removing the products of oxidation.

The largest electric furnace plant in the world is designed to produce 80-ton electric furnace heats of aircraft steel from the melt-down product of 200-ton tilting open hearths. Also, one large producer is combining 130-inch special design cupolas with 12-ton converters and 40-ton electric furnaces. Each of the four cupolas used in this installation (when operated continuously) will provide the converters with upwards of 600 tons per day of partially desulphurized iron. This will be delivered as medium carbon steel from the acid converters, dephosphorized, and the carbon reduced by a special slag practice in the electrics. The charging of four converter heats to make one electric furnace heat will have the advantage of obtaining complete and rapid slag reaction. This project represents a most intensive study of European and American practices by a rather large group of men, each of whom could qualify as an authority on some phase of the operation of the cupola, the bessemer, or the electric furnace. The undertaking promises to more than double the production of electric furnace steel from the 40-ton electric furnaces now working on cold charges. The saving in power, electrode consumption and refractories should be readily evident to anyone interested in making a study of the project.

In this operation the cupolas are specially designed to operate over a relatively long period of time without shutting down for repairs. It is intended to charge turnings, borings and other lighter grades of scrap into the cupolas, using unconditioned scrap, where possible, as well as crushed, baled or briquetted turnings, when necessary.

In either the blast furnace-open hearth or the cupola-converter combination with the electric furnace, the production from the electric furnace should be very much increased with greatly reduced power and electrode costs. Production from the electric furnace, at rates approaching 20 tons per hour and power consumption under 200 kw per ton, can be expected from these units.

The time required to make an electric furnace heat depends on many factors, most of which are not directly connected with the melting practice. There are, of course, minor delays incidental to operation. In many plants these are of a more serious nature in the aggregate than is usually realized. Every possible effort should be made to get the equipment and operation worked out to reduce delays of any type to the absolute minimum.

The three principal causes of lost time, which show a possibility of correction, are (1) delays incidental to the charging; (2) the chemical laboratory service, and (3) the deoxidation period.

# The Increasing Importance of the Bessemer Process

**By S. J. CRESWELL**

Superintendent Open Hearth No. 3 and Bessemer Department, Carnegie-Illinois Steel Corporation, Chicago, Illinois

▲ RECENT study in bar and semi-finished products indicated an increase to 200 applications for bessemer steel as compared to 122 in the prewar period, with an additional list of 27 probable applications. This does not consider the use of blown metal in open hearth furnaces, where it is estimated that 7,000,000 tons were used in 1942.

Present day information indicates that many of the differences in properties between bessemer and open hearth steels are caused by relatively slight and frequently unrecognized differences in chemical composition. As these differences are reconciled and advantage is taken of modern techniques, the field for bessemer steels expands.

Nitrogen and phosphorus are probably the principal determinants of bessemer steel. The former is derived from the blast during the blow. The latter is not changed during the blow.

For an identical carbon content, bessemer steel will average about 15,000 psi higher tensile strength than open hearth steel, while its ductility is somewhat superior. It has in general a very acceptable record in regard to weldability, and its machinability is unequalled.

Recent investigation of fully killed bessemer steels and slight changes in chemical specifications have made possible the use of thousands of tons of bessemer steel in seamless tubing. So-called "brittle failures" occasionally encountered with rimmed or capped bessemer steel have not been experienced with the fully killed product. This development opens up the possible use in other applications formerly thought to be wholly open hearth applications.

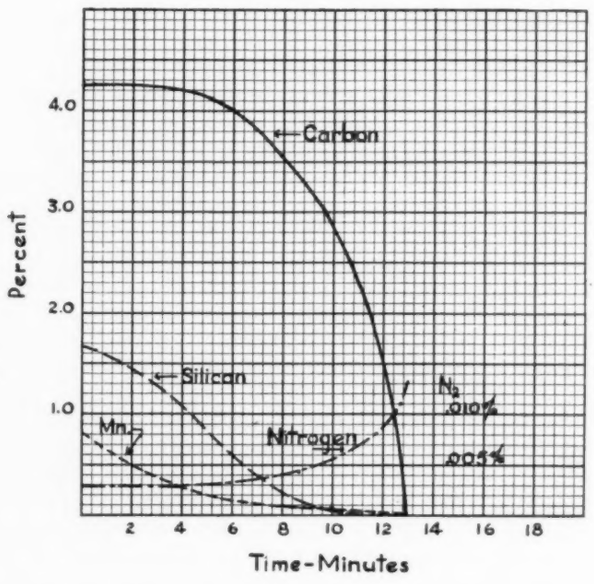
A number of refinements in the bessemer process have contributed to the production of uniformly higher quality steel. Among these are the spectroscope, the photocell, improved blowing equipment, and temperature control.

It is recognized that there are certain fields in which the normal bessemer product, because of its high phosphorus content, nominally .080 to 100 per cent is noncompetitive with soft basic open hearth steels. The difference between the physical properties of bessemer and open hearth steels of similar carbon contents may be reduced by various dephosphorizing techniques. Several methods of dephosphorizing bessemer steel have been patented, among which are those developed by C. B. Francis, by G. M. Yocom, and by C. D. King. The latter two processes have been employed on a tonnage basis during recent years.

Briefly, the Yocum method entails the treatment of the steel in the ladle with a cold dephosphorizing mixture of lime, roll scale, and fluorspar. For its success an effective separation of the acid slag from the molten steel is required. Controlled molten pig iron analysis and blowing practice results in a vessel slag of proper viscosity which is retained in the converter by placing a block of wood across the nose of the vessel during the pouring of the heat. Yocum reports that on working to an 0.040 per cent maximum phosphorus, 98 per cent of the heats will be within the specification and of these, 20 to 30 per cent will fall within the range .020 to .030 per cent phosphorus.

The King method makes use of the slag retained in a tilting open hearth furnace from a low carbon basic open hearth heat. If necessary, this slag may be enriched by the addition of burnt lime and roll scale. The furnace is charged to capacity as rapidly as possible with the required number of bessemer blows and the heat tapped within thirty minutes of completion of the charge. The necessary ferroalloy additions are made to the steel ladle during tapping of the heat. This method is capable

**Typical bath analysis during bessemer blow. Charge, 45,000 lb of hot metal at 2430 F; 5000 lb scrap.**



of consistently reducing the phosphorus content from .090 per cent in the blown metal to .010 per cent in the finished steel.

It is found, however, that if the phosphorus content, as well as the other elements commonly determined, are the same as in stationary basic open hearth steel, in general the yield point and ultimate strength will be higher and the elongation less for the dephosphorized bessemer steel.

Yocum in summarizing the characteristics of this type of steel, states:

"The steel has rather distinct properties of its own and in certain products it is better than either open hearth or regular bessemer steel. It has good welding and machining qualities of normal phosphorus steel and some of its stiffness and reaction to cold work, but a much lower degree of brittleness under impact stresses. On the other hand, it has properties of ductility comparable to a low carbon open hearth steel of about .070 per cent phosphorus content but with a better threading and welding quality. It should be applicable to many products in addition to the tubular goods and flat rolled sheet products for which we have used it."

# Effects of Temperatures on Blooming Mill Production of Hot-topped Steels

**By H. J. FORSYTH**

Republic Steel Corporation, Buffalo District

Specific points discussed are:

1. Effects of varying ingot temperature on rolling rates, efficiency of personnel, power consumption, and surface quality in representative blooming mills.

2. Responsibilities of the blooming mill in controlling surface quality of typical killed steels.

3. Possibilities for improvement of temperature practices with present equipment and operating conditions.

Average results of tests on all important grades and sections rolled on the mill showed that 20 per cent in rolling time was saved as temperatures increased from the lowest to highest observed during normal operations. The effects of temperature remained constant regardless of the time ingots had been soaked before rolling, and this indicates that long heating cycles have little value in expediting rolling unless temperature is closely controlled. The importance of uniform heating is attested by the fact that rolling time for unevenly heated ingots averaged 20 per cent in excess of that required for all other ingots observed.

Temperature had most effect in the bullhead and 12 in. grooves where torque on the drive motor is greatest. Below 2,040 F, lighter drafts (and thus extra passes) were required during bullhead drafting to avoid stalling the drive motor. These decreased in frequency as temperature rose and seldom were necessary above 2,080 F where "stiffness" during rolling disappeared.

During rolling, ingots were in contact with the rolls for only 55 per cent of the total time they were on the mill. This indicates the possibilities for increased production through development of faster manipulation equipment, roll screws and delivery of ingots to the rolls.

As temperature increased from 2,020 F-2,1280 F, power required to roll ingots of A. I. S. I. 1035-50 decreased 22 per cent. A. I. S. I. 9255 showed the same relation in a lower temperature range, although it required 10 per cent more power than lower carbon grades rolled at the same temperatures.

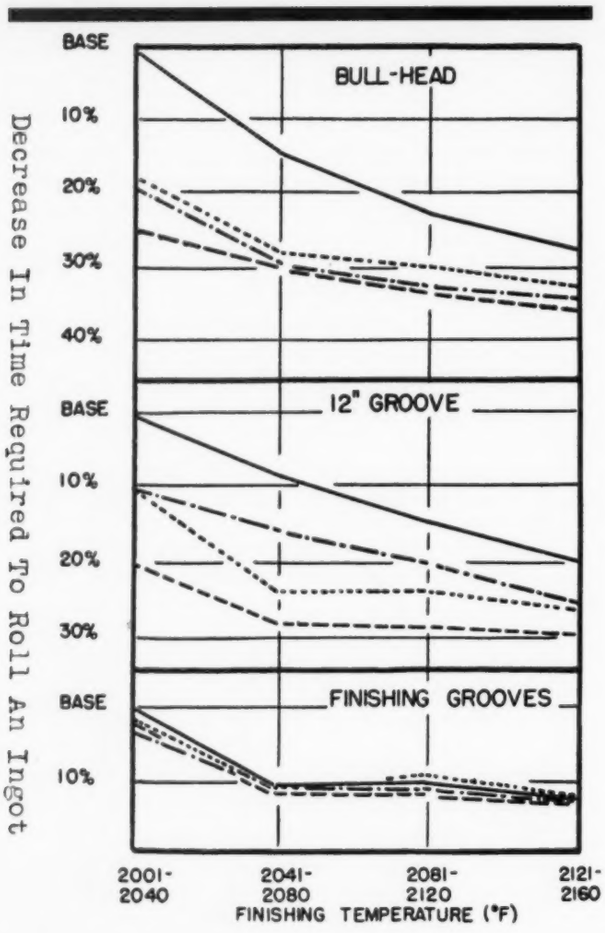
The rollers' regulation of drafts in the breakdown passes largely determined the extent of power variations, since passes which did not perform useful work increased power consumption. However, there were a few cases where extra passes permitted better speed although power consumption was increased. Such instances were noted when hard grades such as A. I. S. I. 9255 and file steels were rolled.

Killed steel surface requirements offer few opportunities for reduction or complete elimination of billet conditioning. As a result, representative mills find that conditioning man-hour requirements per billet ton of killed steel produced exceed those for open grades by as much as 300 per cent. Therefore it is important to determine the blooming mill's responsibility in control of billet surface and evaluate the effect of temperature on surface quality.

Killed steel heating practice should aim for much heavier scale than desired for open grades which often contain subsurface defects that cause serious trouble if uncovered by excessive scaling. Time and temperature govern scale thickness, and longer soaking times are generally considered the most effective means of improving ingot surface. Since heating times must be drastically curtailed at present to maintain production schedules, full attention must be given not only to temperature control but also to factors which affect original ingot surface on killed steel.

Tests reported in this paper show that ingots from bare molds heated with good temperature practice produced billets which required 62 per cent more scarfing than those produced by ingots from coated molds heated in the same soaking pits. At lower soaking temperatures, bare molds increased scarfing by 100 per cent. On the other hand, high and low soaking temperatures produced only 18 per cent difference in conditioning on product from coated molds as compared to 58 per cent on product from bare molds. These results demonstrate that ingot surface is the most direct and effective control of billet surface.

The range 2,300-50 F is generally considered satisfactory soaking temperature practice for 0.25-0.55 C open hearth killed steels, while lower carbon grades are usually soaked at 2,350-2,400 F. The time ingots should be soaked at these temperatures is usually specified to assure reasonable salvaging of surface. Since it was found that mills can usually attain desired temperatures but cannot meet soaking time requirements without sacrificing production, it became important to determine if temperatures 50-100 F higher could be safely




**The influence of temperature upon rolling time is particularly marked in the bullhead and 12 in. groove passes.**

used to effect surface improvement and at least partially compensate for curtailments of soaking time.

Ingots below 0.25 C were subjected to soaking temperatures of 2,350-2,400 F and 2,400-50 F. The medium carbon grades were soaked at 2,300-50 F and 2,375-2,425 F. Billets varied from 4 in. to 7¾ in. square and were scarfed free from all defects visible after pickling. As shown, higher temperatures effected average savings of scarfing which ranged from 34 per cent on A. I. S. I. 1015-20 to 17 per cent on the medium carbon alloys.

Reduction of seaminess almost entirely accounted for surface improvement affected by the higher soaking temperature, and this must be attributed to acceleration of scaling during heating.

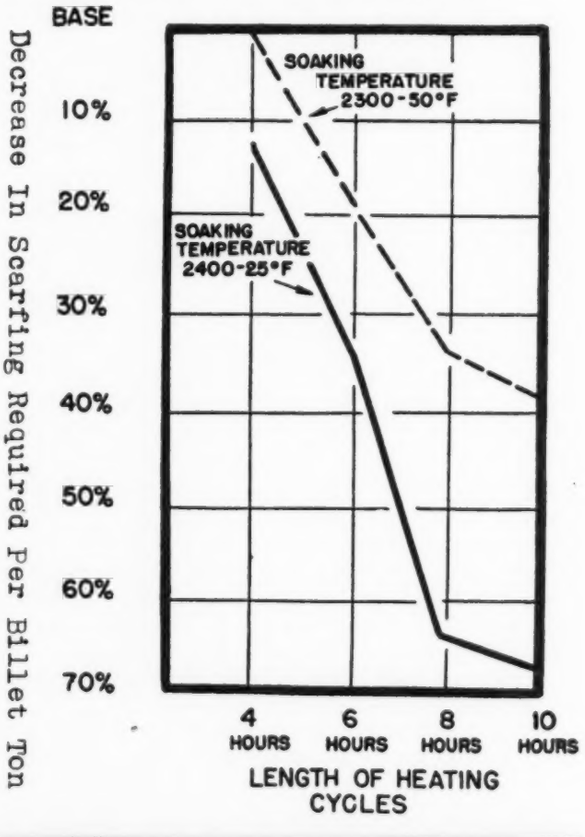
It was also demonstrated that although longer heating cycles were valuable in improving billet surface, this improvement was greatly accelerated by higher soaking temperatures. For example, ingots soaked at 2,400-50 F during a six-hour cycle had surface quality equal to those soaked at 2,300-50 F during an eight-hour cycle. It is clear that heating time is not used to fullest advantage in billet surface improvement unless soaking temperature is maintained at highest practical levels.

Of the 4,000 tons of billets involved in experiments, only two tons were scrapped because of burned surface. A few cases of lightly burned or checked surface were observed, but 40 per cent of these came from pits soaked at normal temperatures. Thus, it appears that irregular fuel reversals, too rapid initial heating, and infiltration of excess air through leaks in the soaking pit are sources of burned surface which may be often incorrectly attributed to high soaking temperature. All billets having burned surface were included in foregoing summaries of results.

Excessive washing caused trouble with scale on pit bottoms only when temperatures exceeding 2,2425 F were maintained for long periods. However, little difficulty was encountered during normal or short heating cycles. Scale loss undoubtedly will increase from consistent use of higher soaking temperatures but should be more than offset by less removal of billet surface during scarfing, less scrap due to surface defects, higher efficiency of mill production, general economies in billet conditioning, and improvement of finished products.

Heating practice which attains proper rolling temperature does not necessarily use available time to best advantage for improvement of ingot surface. Scarfing is saved by the longer soaks at rolling temperature. Heating practice must consider both ingot surface improvement and rolling temperature. Heaters should aim to reach a good scaling temperature as rapidly as practical and maintain it for the balance of the cycle. Rapid initial heating is the most difficult phase of temperature practice and must have close attention during its execution, but it will allow maximum improvement of ingot surface for a given heating cycle.

**Comparative effects of soaking time and temperature on billet surface. A. I. S. I. 1040-50, 6— in. square billets, pickled and scarfed free from surface defects.**



# Production of Steel Plates

**By C. L. McGRANAHAN**

Assistant General Superintendent, Jones & Laughlin Steel Corporation
Pittsburgh Works

▲ ONE of the perplexing problems facing industry previous to December 7, 1941, was the production of sufficient plates to take care of a two-ocean Navy, to provide 8,000,000 deadweight tons of shipping, to fabricate 45,000 tanks annually for the Army, and to provide for a multitude of defense projects and essential civilian needs, a requirement conservatively estimated at 8,500,000 to 9,000,000 tons a year and being produced at a rate of 6,300,000 tons. Inasmuch as this deficiency seemed likely to increase when the Maritime Commission ship program reached its peak in the third quarter of 1942, a total of 2,336,920 tons of additional plate capacity was approved by O. P. M. officials. This included 654,000 tons from revamping strip mills; 142,920 tons from new capacity at Tennessee Coal, Iron and Railroad Company; 780,000 tons by Bethlehem Steel Company; and 760,000 tons by Carnegie-Illinois Steel Corporation.

Events after Pearl Harbor transpired so rapidly that estimated plate requirements soon reached the 10,000,000 mark with desires expressed for at least 12,000,000 tons if possible. The first estimate of 8,500,000 or 9,000,000 tons when matched against a theoretical annual capacity of 7,000,000 tons did not seem too far beyond the realm of possibility, but the figures of 10,000,000 and 12,000,000 tons pointed to the necessity for immediate increase in production through technological changes to existing plate mills and continuous strip mills. It was apparent that, except for one new plate mill scheduled for operation in May 1942, no appreciable help could be secured from the other new projects before autumn of 1943. The additional tonnage above 7,000,000 tons, would therefore have to come principally from the continuous strip mills whose pre-Pearl Harbor output was 152,440 tons in October, 1941.

The situation was adequately described in a release from the War Production Board dated February 4, 1942, from which we quote in part:

"The industry has, at present, capacity to produce 932,100 tons of plate a month, coming from 77 mills.

"These comprise twenty-eight sheared plate mills with a total monthly capacity of 401,100 tons; twenty-two universal plate mills with a total monthly capacity of 125,000 tons, and twenty-seven strip mills with a total monthly capacity of 406,000 tons.

"The rated capacities were predicated on an average range of orders and on present shearing and other finishing facilities. Furthermore, due allowance was made in certain instances for other important steel products urgently needed in the war program and produced on the same equipment.

"Included in the strip mill tonnage are ten wide continuous strip mills, operated by nine companies, all of which can produce plates up to 72 inches wide, and three of which can produce plates up to 90 inches wide. The combined monthly plate capacity of these ten mills is 303,500 tons. Maximum thicknesses produced on these mills vary from $\frac{3}{8}$ to $\frac{3}{4}$ inches.

"Among the sheared plate mills there are only thirteen operated by eight companies, which can produce plates 90 inches and wider, more than $\frac{3}{4}$ of an inch thick. The combined plate capacity of these mills is 227,300 tons per month.

"It is in the last mentioned category that there appears to be the greatest demand for plates for the war program. It is, therefore, essential that no plates be produced in these mills which can be rolled on other mills and that, to the greatest extent possible, requirements be redesigned to permit their production on the strip mills.

"There is now under construction additional capacity which will be available at various times throughout 1942 and into the early part of 1943, totaling 46,000 tons per month. Most of this capacity is in sheared plates.

"Due to various size limitations, it is not thought likely that the full capacity of 932,100 tons per month can be attained. However, the industry should be able to produce well over 800,000 tons of steel plates per month."

Any doubts regarding industry's ability to meet the W. P. B. estimate of 932,100 tons were dispelled by the end of May, 1942, when a total of 1,012,194 tons of plate was produced. Continuous strip mills' share of the tonnage was 425,211 tons or 2.8 times the October 1941 figure.

This unprecedented production of plates on continuous strip mills was not accomplished without attendant headaches or without encountering and overcoming many discouraging problems. In most cases, extra finishing capacity was required, such as levelers, tables, pilers, shearing equipment, etc. Some plants required longer pilers and heavier shears. Other plants were able to use old finishing equipment from idle sheet mills, in some cases combining old units into effective operating units.

In order to bring about this remarkable increase in plate production, it was necessary to point out to the W. P. B. that room did not exist in most plants to erect sufficient side shearing equipment to trim over one-third of their rolling capacity. It was further pointed out that practically every ship plate was cut to a templet and that a good mill edge should therefore be satisfactory. The request to furnish mill edge was granted and has been one of the most vital factors in raising production 25 per cent over the February, 1942 estimate.

The 10-million ton steel expansion program announced by O. P. M. officials on September 30, 1941, contemplated additional sheared plate capacity of 1,682,920 tons distributed as outlined in the early paragraphs of this paper.

The increased capacity to be gained from changes at one of the plants of the Tennessee Coal, Iron and Railroad Company began materializing in May, 1942, when a new 140 in. 4-high reversing stand started operations in tandem with an existing 110 in. 3-high plate mill. It is estimated that this will ultimately increase the production of this plate mill from 160,000 tons annually to slightly over 300,000 tons. This installation has been the major one to date to contribute to increased plate production on sheared plate mills.

The rapid increase in total plate production during

## TABLE I

### Steel Plate Shipments by Mill Types

### (Net tons)

| | Universal | Sheared | Strip | Total |
|---|---|---|---|---|
| 1941 | | | | |
| October | 94,311 | 346,401 | 152,440 | 593,152 |
| November | 99,828 | 350,838 | 169,311 | 620,007 |
| December | 113,467 | 358,273 | 182,604 | 654,344 |
| 1942 | | | | |
| January | 122,227 | 381,899 | 250,396 | 754,522 |
| February | 111,965 | 377,770 | 268,988 | 758,723 |
| March | 123,152 | 449,379 | 306,195 | 878,726 |
| April | 121,838 | 436,614 | 337,519 | 895,971 |
| May | 125,608 | 461,375 | 425,211 | 1,012,194 |
| June | 123,114 | 438,144 | 489,704 | 1,050,962 |
| July | 126,100 | 447,481 | 550,537 | 1,124,118 |
| August | 115,710 | 430,197 | 551,959 | 1,097,866 |
| September | 115,372 | 434,555 | 511 909 | 1,061,836 |
| October | 114,506 | 449,895 | 536,981 | 1,101,382 |
| November | 114,755 | 424,708 | 474,136 | 1,013,599 |
| December | 114,650 | 454,902 | 490,487 | 1,060,039 |
| TOTAL | 1,428,997 | 5,186,919 | 5,194,022 | 11,809,938 |
| 1943 | | | | |
| January | 121,039 | 448,481 | 565,893 | 1,135,413 |
| February | 118,519 | 424,167 | 529,315 | 1,072,001 |
| March | 138,805 | 465,572 | 563,302 | 1,167,679 |

the first six months of 1942, indicated the desirability of modifying these plans and in July, 1942, the Iron and Steel Branch of the War Production Board announced a revision of its program as follows:

The 132 in. semi-continuous high speed plate mill originally allotted to the Bethlehem Steel Company by the Defense Plant Corporation was transferred to the Columbia Steel Corporation for erection in Utah in place of the 110 in. conventional mill originally scheduled for there. This mill is rated at 760,000 tons annually with a range of 120 in. finished width and a maximum thickness of 1½ in. The layout provides four separate finishing outlets and undoubtedly is one of the finest layouts produced to date. In the writer's opinion it should greatly exceed its rated capacity if provided with sufficient slabs. This mill should go into operation late in 1943.

A 110 in. 2-stand tandem plate mill was approved for the Kaiser interests to be located in Southern California. This mill consists of a 2-high roughing stand and a 3-high finishing stand with the necessary tables, shears and levelers. It has an estimated capacity of 300,000 tons annually, a maximum width of 11 in. and thickness of 1½ in. and should be in operation by late summer this year.

The 160 in. single stand 4-high plate mill of the Carnegie-Illinois Steel Corporation is being erected in the Pittsburgh district in accordance with original plans. This mill is rated at thicknesses up to 6 in. It will be supplied with both shears and flame cutting equipment to handle this extreme range of thicknesses. It is expected that this mill will go in operation during the latter part of 1943.

The erection of a 110 in. 3-high plate mill in Texas by the Sheffield Steel Company was authorized and contemplates the use of a rolling stand formerly in operation in the Youngstown, Ohio district. This mill should be able to produce in the neighborhood of 215,000 tons annually in width of 100 in. and thicknesses up to 1½ in. Plans call for its operation during the summer of 1943.

Work is progressing on the new 120 in. finishing stand which is being installed at the Lukens Steel Company in tandem with the present 112 in. mill. This equipment is being installed to increase facilities for handling and shipping rolled armor plate and will be in operation later this year.

# The Wire Industry and the War Effort

**By J. S. RICHARDS**

Director of Research, American Steel and Wire Company, Cleveland, Ohio

▲ THE wire branch of the steel industry has been faced with thousands of uses for its products in war. Nails, barbed wire, staples, chain link fencing, and fastening devices of many kinds are used in huge quantities, as well as bolts, nuts, rivets, etc. Wire rope is used for aircraft ropes, balloon cable, arresting gear ropes, bomb hoist cable, towing cables, submarine nets, mine sweeping ropes, etc. Of great value in the war effort was the development of high grade spring wire, eliminating our dependency upon imports from Sweden.

The new wartime applications of springs with their high stress requirements have been met by the wire industry with new compositions in both alloy and carbon steels and with new wire drawing and heat treating procedures to produce the qualities necessary in the finished wire and springs. Industry has complied with these quality requirements and still has met the greatly increased volume demand necessitated by domestic and lend-lease requirements. Some of the more important war-time uses of spring wire and springs are: light arms, artillery, bombs and projectiles, mines and torpedoes. In aircraft are valve springs, plane controls, instruments and bomb releases; chemical warfare uses include gas masks and incendiary bombs.

One of the most sensational rises in volume of output by the wire industry has been effected in welding wire. This product, both stainless and carbon steel, has been of tremendous value in helping to set production records of ships, planes, tanks, guns and other armament. During the second half of 1941, a total of 5,471,541 pounds of stainless welding electrodes were produced; during the comparable 1942 period, this total had been raised to 19,831,222 pounds, an increase of 262 per cent.

The total of all welding electrodes — both stainless and carbon — during the last six months of 1941 was 209,154,319 pounds; the last half of 1942 saw production of 384,788,738 pounds, a gain of 84 per cent. The vast volume of testing necessary to retain the high standard of quality for welding wire has been maintained while achieving these phenomenal production records.

One of the outstanding uses of steel in the electrical field is in the manufacture of composite copper-steel wire serving in lieu of bronze wire as an electrical conductor. Typical of this general type of application is the extensive use of 0.0095 in. and 0.0126 in. steel wire, which is stranded with copper wire to form a conductor suitable for standard signal corps assault and field wire. Three steel wires are stranded with four copper wires to provide long lengths of efficient electrical conductors with sufficient strength to withstand the rigors of wartime use in the field.

Transmission of electrical power over steel wire was not foreign to the electric industry prior to the war inasmuch as it had been used in conjunction with copper and aluminum conductors. With the practically complete elimination of those two strategic metals for such installations, special electrical grades of steel conductors filled the requirements for countless transmission lines to industrial plants and military installations.

Fine galvanized steel wire has also replaced aluminum in another important application. It is now being used for armoring shipboard cable.

General recognition of the possibilities, as well as limitations, of steel wire as a conductor has led to sound application of insulated and covered steel wire for certain services such as service drop cables, communication lines and lightning shielding protection for vital ammunition centers.

An outstanding example of cooperation and maximum use of available material and equipment was in the development of manganese-molybdenum steel to replace the "Before Pearl Harbor" tungsten steel used in bullet cores.

The small quantity peacetime and lend-lease requirements of .30 and .50 caliber machine gun armor-piercing ammunition had been developed on the basis of using electric furnace tungsten steel and centerless ground bars heat treated for machineability. After Pearl Harbor manufacturers faced with the program of producing unheard of quantities of this commodity had three seemingly insurmountable obstacles to overcome. First ¼ there was not enough tungsten in the country or available for the steel; second — electric furnace capacity available to produce the steel was far short of requirements; third — it would take years to build the centerless grinders necessary to finish the required tonnage.

The wire industry had cold drawing capacity and heat treating practices and equipment to produce the tonnages required but did not have nor could it get the needed electric furnaces or grinding equipment to begin mass production. With the cooperation of technicians from the government arsenals the wire industry produced from open hearth, cold drawn, heat treated and straightened bars, the unprecedented quantities required and at the same time released for other uses the badly needed electric furnace and grinding equipment. In addition, the machining time of the bullet cores was decreased by one-half.

# The Conservation of Critical Materials

**by C. H. HERTY, JR.**

Assistant to Vice President, Bethlehem Steel Company

▲ THE problems involved in conservation of critical materials in the steel industry are of three types.

1. Problems arising from a general increase of total steel tonnage.

2. Problems arising from a change in the steelmaking process due to changes in raw material availability.

3. Problems arising from increased tonnages of certain grades of alloy steel due to changes in end product pattern, combined with a general increase in tonnage of alloy steel end products.

Problems of the first two types are generally predictable and steps can be taken to ease any particular situation before the problem becomes acute.

Problems of the third type usually arise rather suddenly, precipitating intense activity in the field of conservation of one or two elements. The tendency under these circumstances has been to shift the load through substitution of standard or new steels to some alloy or combination of alloys which was less critical at the moment.

Chronologically, manganese was the first element to receive attention on conservation, and steps were taken in 1940 to insure adequate supplies of manganese. At that time there was a stock of about 1½ years of manganese ore in this country. Three distinct steps were taken at that time. (1) Arrangements were made for the continual procurement of foreign ores sufficient not only to supply current needs but also to increase stocks. (2) A committee of the National Academy of Sciences began a review of domestic resources and processes for beneficiating domestic ores. (3) An American Iron and Steel Institute committee reviewed, for the industry, the possibility of manganese conservation, through changes in specifications and changes in steelmaking practice.

As a result of these various activities, the manganese position has been comfortable, with good prospects of a continuation of an adequate supply of manganese.

At the present time, the consumption of manganese per ton of steel is increasing due to the increased tonnage of alloy steel being produced and the increased use of manganese as an essential element in its substitution value for other more critical elements, particularly chromium and molybdenum.

The consumption of metallic manganese as pounds per ton is as follows:

| | |
|---|---|
| 1940 | 11.0 |
| 1941 | 12.0 |
| 1942 | 13.1 |

Early in 1941 there were indications that the supply of deoxidizing aluminum might become critical. With the signs pointing toward a shortage, the industry

generally began to curtail the use of deoxidizing aluminum by substitution and careful use of this material. The substitutions generally used were ferro-silicon, alsifer (an aluminum-silicon-iron alloy), ferro-titanium and silico-manganese.

The consumption of metallic aluminum in pounds per net ton of ingots is as follows:

| | |
|---|---|
| 2nd half 1940 | .698 |
| June, 1941 | .562 |
| October, 1941 | .562 |

The reduction in consumption was sufficient to relieve the situation and the W. P. B. issued an order restricting the use of aluminum in carbon steel to 0.60 pounds per ton, and in alloy steel to 2.0 pounds per ton. Special requirement steels, such as nitralloy or full killed deep drawn sheet steel were treated as special cases. The ruling on pounds per ton applied to the tonnage of steel in a company or plant and not to specific grades of steel.

In recent months, the position on ferro-silicon has become tight due to the heavy demands on all electric furnace ferro-alloys and the increasing tonnage of alloy steels which require more silicon than the average carbon steel. The consumption of 50 per cent and higher grades of ferro-silicon was 2.2 pounds silicon per ton of steel in January 1942 and 2.6 pounds silicon per ton of steel in December 1942. This increase was due almost entirely to the increased production of alloy steel during this period. Although the situation is expected to ease within the next six months, the industry is attempting to conserve ferro-silicon by working to the lower limits of specifications and by using blast furnace rather than electric furnace silicon pig for furnace deoxidation.

With the increasing tonnage of steel ingots and with the rapid rise in the production of alloy steels, the consumption of fluorspar has increased steadily in the past year, and there exists a potential shortage of this important steelmaking material. In order to alleviate the situation, various steps have been taken to increase the production by changing specifications, by price adjustments and by the development of new fluorspar deposits in this and adjacent countries. A considerable amount of conservation has been accomplished by the increased use of roll scale and efforts to prevent the unnecessary use of fluorspar wherever possible. Experimental work is being conducted on various substitutions for fluorspar.

It has been found that a large percentage of the ore charged in high hot metal heats can be soft Lake ores. The degree of fineness, the silica content and the combined water are the three major factors in determining the limits in which the soft Lake ores could be used in the open hearth charge, and it is recommended that the maximum possible use be made of soft ores. After this maximum has been reached, it is necessary to utilize either hard ores or prepared ores. Open hearth sinter, nodulized ore and ore briquettes are now being produced in considerable quantities to make up the difference between the soft ore which can be charged, the lump ore which is available and the total ore required.

A major factor in the production of alloy steel has been the recovery of alloys from scrap. The average alloy ingot produced in this country results in a steel distribution as follows:

| | |
|---|---|
| Finished product | 35.8 per cent |
| Solid scrap | 38.6 |
| Turnings | 17.6 |
| Loss | 8.0 |
| | 100.0 per cent |

The total scrap from the ingot is divided between that produced in the steel mill and in the consuming industries. The recovery of alloy in the steel mill scrap is quite efficient provided that careful segregation is observed and that no radical changes in steel grades are encountered.

Scrap returned to steel mills from the consuming industry has been a real problem. Thus variations in grades of steel made in different districts impose a handicap on the proper use of the scrap generated. The four largest tonnage grades of alloy steel made during the first quarter of 1943 were:

| | |
|---|---|
| Cr-Mo | 22.8 per cent of total alloy steel |
| Ni-Cr-Mo | 20.4 per cent of total alloy steel |
| Mo | 15.9 per cent of total alloy steel |
| Ni-Cr | 9.3 per cent of total alloy steel |

It is estimated that there are about 200,000 tons of alloy turnings produced per month. A number of steps have been taken for maximum utilization of these turnings. The four general preparation methods are: screening, crushing, briquetting and baling. Turnings are often burned prior to treatment, the burning eliminating the oil and rendering the metal brittle. Too high a percentage of burned turnings cannot be used due to the oxidation of these turnings.

In some plants, alloy turnings are charged into blast furnaces, the pig iron produced containing nickel, chromium and molybdenum. This enables an increased recovery of alloys over that possible by charging alloy scrap and alloy-free hot metal, but results in wastage of at least one alloy unless the iron is used on Ni-Cr-Mo steels.

A survey conducted by an A. I. S. I. committee indicated that about 11 per cent of turnings (based on ingot production) were being consumed, but that the consumption varied from 2 per cent to 18 per cent in different plants. It has been recommended that all alloy steel producers be required to use at least 8 per cent (based on ingots) of alloy turnings in the charge, and that Ni-Cr-Mo type steels be adopted whenever possible to increase the possibility of utilizing all the alloy turnings produced.

In the common alloying elements, the following approximate recoveries are currently being obtained from scrap:

| | |
|---|---|
| Nickel | 45 per cent of alloy in ingots |
| Molybdenum | 35 per cent of alloy in ingots |
| Chromium | 20 per cent of alloy in ingots |

At the present time, the most critical of the above three elements is molybdenum, and one of the factors which must enter into the solution of the molybdenum problem is the full utilization of molybdenum-bearing scrap. Much molybdenum-bearing scrap is returned to steel plants mixed with other scrapand can only be utilized efficiently in nickel-chrome-molybdenum steels. Such steels, in addition to utilizing mixed scrap, consume less of any given alloy than singleor bi-alloy steels.

# Plant Production Problems Presented by Sustained High Level Operations

By E. C. WRIGHT

Chief Metallurgist, National Tube Company, Pittsburgh

▲ THE production of steel depends upon a careful balance of the mining, smelting, heating, rolling and finishing operations involved. Normally, supplies of raw materials, semi-finished goods and finished stocks are accumulated at the various producing stages. These supplies serve to cushion the producing units whenever interruption or breakdown occurs on some preceding operation. The demands upon the steel industry during the past two years have practically eliminated stocks and other surplus supplies. As a consequence the problem of providing a continuous flow of materials to each stage demands the most careful planning and scheduling.

In 1942, more than 550,000,000 tons of bituminous coal were mined. This tremendous demand for coal has made it necessary to work out old mines and develop new coal deposits. Current problems relating to manpower have accelerated the trend to mechanized mining. These factors have generally resulted in coal of less uniformity and as a consequence the installation of coal blending and coal preparation plants has been necessary in many cases, and several more are under consideration.

Statistics of iron ore production show that most of the mining districts have increased their production nearly three-fold in the past eight years in spite of the problems involved in mining, beneficiation, transportation and depletion of reserves. In the Adirondack region, new mines and new ore dressing plants have been built, and mining and beneficiating equipment extended in the Lake Superior and Birmingham districts. This has necessitated deeper mining, removal of more overburden from new surface mines opened, and the treatment of a considerable quantity of lower grade ore to make it suitable for good blast furnace production. The greater tonnage of fine ore mined in the Lake Superior district, and the necessity of crushing, washing and concentrating of leaner ores has greatly increased the proportion of fine ore produced. Since the smelting of extremely fine ores in blast furnaces operated at high wind pressure for maximum production results in a large loss in blast furnace flue dust, it has been necessary to install extensive sintering equipment not only at the blast furnace but at concentrating and beneficiating plants.

Some of the main factors which have had to be faced in the open hearth plants operating at full capacity are listed below:

1. Scarcity of melting scrap and decrease in quality of scrap.
2. Increased use of pig iron in open hearth charges.
3. Shortage of proper quality charge ore and feed ore.
4. Fuel supply.
5. Changing from industrial products to war materials.
6. Inadequate auxiliary equipment.
7. More hot top ingots.
8. Greatly increased tonnage of alloy steel.

Most of the steel now being produced is directly for war purposes. This has required the melting and finishing of practically a new line of steel products made to specifications which are generally more exacting than those encountered in ordinary commercial practice.

The amount of alloy steel melted in the United States has increased from 3,329,657 tons in 1936 to more than 11,000,000 tons in 1942. Alloy steel production has many peculiar features not common to mild carbon steel operations. Some of the more important differences are listed below:

1. More difficult chemical specifications and greater rejections.
2. Missed heats which will meet specifications for other orders.
3. More hot topped ingots with more time at pouring platform and longer time in soaking pits.
4. Increased heating time in soaking pits with "stickers" and banked ingots.
5. Frequent requirement for slow cooling of rolled products.
6. Heat treating or annealing of finished material.
7. More thorough and costly conditioning of steel surface before and after rolling.
8. Lower production yield from ingot to shape.

Many alloy steels have characteristics entirely different from mild carbon steels. They must be heated more slowly and carefully to a more precise forging or rolling temperature to prevent bursts or ruptures. The rolling or forging of alloy steels often requires reduced drafts which slow up the rolling mill production. The rolled product frequently must be slowly cooled to control the properties or to prevent such defects as flakes.

The surface quality of the alloy steel products are generally more rigid and they are troublesome to condition due to the fact that many of them may be dressed most satisfactorily with grinding wheels or chipping hammers.

The rolling and finishing capacity of many steel mills exceeds the production of steel ingots. However, during this emergency the change in product has been so extensive that rolling mills designed for one purpose have had to be adapted to the production of an entirely different product.

That tremendous effort has been expended to provide means with which to reduce the time required to complete major repairs is attested to by the weeks of operating time that are now saved in relining a blast furnace. By reason of scheduling and accelerating repairs and rebuilding, the availability of open hearth furnaces has been greatly extended. Auxiliaries, installed to take care of production far below that now obtained, have put additional burdens on maintenance. Lack of standby blower capacity, insufficient ladle supply and inadequate soaking pit facilities contribute to the many problems with which operators are constantly confronted today. Thus maintenance has a dual problem — that of keeping equipment in continuous working condition until repairs are scheduled, and that of minimizing the time for rebuilds and repairs.

During high level operations the allocation of ingot tonnage and the scheduling of mills to the required production without loss in finished production are problems of first magnitude. Its solution involves developing and coordinating a multiplicity of relatively small and seemingly unrelated factors into a plan which so well fits the plant that each department, together with machines and men, may function most effectively. The schedule must be prepared long in advance of actual operations and it must be so flexible that it can be immediately adjusted when unforeseen changes in the nature of product or operation occur.

The problem of providing the men with which to sustain high level operations is aggravated by an increased demand for high quality personnel. Statistics reveal that the steel industry has lost approximately 30 per cent of its total personnel to military service. Shortages of manpower made acute by war conditions necessarily require a readjustment of standards of personnel specifications to include the utilization in production tasks of female employees. To provide interest, high morale and good health, the factors so necessary to personal efficiency, close attention must be given to those matters which have a direct bearing on the individual, such as control of hours worked, rates of pay, provision for proper sanitary facilities, safety, hygiene, transportation and housing. These are very real and material problems which must be met and solved.

# Wartime Scrap Problems

**By F. E. VIGOR**

General Transpotation Manager

The American Rolling Mill Company, Middletown, Ohio

▲ STUDY by the Steel Division of the War Production Board discloses that during 1943 the minimum required generation of purchased scrap is about 24,000,000 net tons if the steel industry shall continue to operate at capacity. Current inventories of all scrap are somewhat higher than they were at this time last year. Only about two-thirds of the increase, however, is in steelmaking grades, the other one-third being cast scrap and foundry grades.

The major proportion of the increase in inventory was built up in the summer of last year. The rate of increase dropped during the autumn, and stocks were drawn down in January and February. In large part this was a seasonal effect and the general situation will probably prevent increasing inventories until May.

The outlook for collections is somewhat doubtful, but it is hoped that collections will at least equal consumption. According to the Salvage Division, War Production Board, about three-fourths of the total amount of required purchased scrap will come from industrial sources, leaving one-fourth to be collected from household, remote sources, and sources of otherwise dormant scrap. The more obvious sources were very nearly exhausted in 1942.

One supply that can be more generally utilized is scrap removed from slag piles. This is being done by many companies, but could be expanded. It has been hoped that battlefield scrap, which ought to be a rather abundant supply of heavy steel, would be available in some quantity. Transportation of this steel is so much subject to strategic condition, however, that this source cannot be relied on. Undoubtedly some will move as ballast when this is possible, but there are many other commodities that can probably use shipping to greater advantage to the national economy as a whole.

There are two main aspects of the scrap problem that can and must be effectively dealt with if the flow of scrap is to be maintained at a rate capable of meeting the demand. (1) Sorting has to start in the plant of the steel consumer, and this initial segregation must be maintained and broken down further by dealers. (2) Any interruption to the flow, whether it arises from failure of consumers to purchase, failure of appropriate agencies to collect, or failure of the scrap producers to make it consistently available, has a profound effect on the entire pattern.

No. 1 heavy melting steel is practically non-existent. Consequently it continues to be necessary for consumers to maintain production with lighter and less desirable grades of scrap. Much has been accomplished in this direction.

To a considerable extent scrap consumers who are equipped, or who can become equipped, to handle light grades can assist themselves in the general situation by using such equipment, but, in general, the gathering, sorting and preparation, and distribution of scrap can be better done by the scrap industry. The huge increase in quantity of light scrap that must be consumed, however, together with the increase in alloy steel production, and necessarily extremely close grading to specifications of alloy scrap, indicate that to some extent direct dealing between steelmakers and steel consumers has many advantages. Frequently this is the only way in which anything approaching a specified analysis of alloy scrap can be obtained.

It is estimated that alloy turnings are appearing at the rate of 200,000 gross tons per month and carbon turnings at about 400,000 gross tons per month. A recent amendment to order M-24 requires that at least 8 per cent of the total charge in heats of alloy steel, excepting stainless, shall be turnings, and of the turnings so used at least half must be long or bushy turnings. As is not unusual with general orders, there are many instances where this is impractical or impossible, and relief from the terms of the order must be had. Nonetheless, turnings will be about 30 per cent of the total volume of purchased scrap that must be obtained during 1943, and they are nearly 40 per cent of the purchased scrap requirements for steel only. The importance of alloy turnings as a source of alloys to maintain and increase the production of alloy steel cannot be overemphasized.

Although Order M-24c makes it mandatory that all alloy steel be separated into eight classes, performance

under this order has fallen far short of the results that can be obtained if the minimum of good housekeeping in this connection were applied in steel consuming plants. Proper segregation and classification will go far to overcome resistance to direct use of turnings. Methods of using turnings, both alloy and carbon, to best advantage have received much attention.

The British have very largely solved this problem by installing a large number of turnings crushers at plants where the turnings are produced. About 54 per cent of the bushy turnings produced in England are crushed into short shoveling grades. They charge much of the balance of the bushy turnings into blast furnaces to improve the grade of pig iron that they can produce and to recover the metal in the turnings as expeditiously as possible.

Inclusion of turnings in blast furnace charges for the production of alloy iron has also received much attention. So far this method has been successfully used up to the point where about 18 per cent of the output of the furnace has been derived from turnings. The method is useful for carbon turnings and, from the point of view of alloy conservation, for turnings that contain nickel and molybdenum. To obtain an effective alloy content in the pig iron, however, the method is limited to high alloy scrap. It probably is most useful as a means of diluting high alloy turnings for the production of N. E. steels. The method is not, however, the answer to all the alloy turnings problems. It is useful to those who find that they can obtain a portion of their nickel and molybdenum requirements from scrap most readily by incorporating them in pig iron.

An alternative to using this variety of scrap in blast furnaces appears to be available in the cupolas of iron foundries, some of which are not now operating more than four or five hours per day. The equivalent of alloy iron can be produced at very low cost and distributed where it is required. This should be investigated by those companies who are having difficulty in direct use of turnings, or who think this method of treating turnings would be useful for any other reason.

Nickel and molybdenum are almost fully recoverable regardless of the processing and use of the scrap. Chromium, particularly in high-chromium grades, is definitely undesirable in any heat where oxidation of carbon has to be done. Chrome-bearing scrap, therefore, can be used to best advantage only in heats in which the net carbon content exceeds that of the scrap. Vanadium is invariably lost in open hearth heats when it is introduced as scrap.

Undesirable alloy elements are usually tramp alloys that appear in supposedly alloy-free scrap or scrap delivered on any other specification. The introduction of nickel and molybdenum into heats that are expected to contain only carbon, silicon, and manganese is not helpful in the production of high grade silicon sheets. Most of the "undesirable" elements that are appearing in scrap are in the scrap only because it is improperly classified.

# A. I. S. E. ANNUAL

# *Engineering Conference*

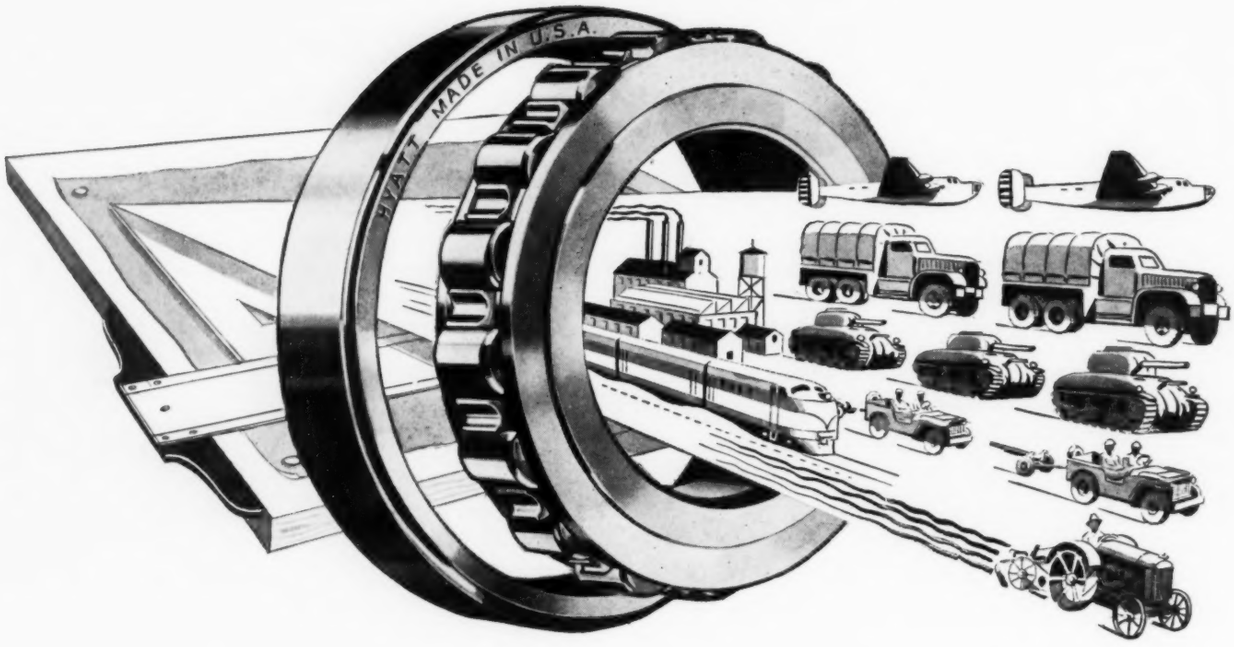
## Pittsburgh, Pa.

## September 28, 29, 30

### *Tentative Technical Program*

Relation of Industrial Engineering to Production.
Steel for Cartridge Cases.
A Temper Mill of New Design.
Gas Economies in the Coke Plant.
Variations in Blowing Rates for Blast Furnaces.
Modern Trends in Blast Furnace Design.
A-c and D-c Drives for Wire Blocks and Draw Benches.
Fire Prevention in Steel Plants.
Electrical Equipment for the Modern Arc Furnace.
Relay Protection for Distribution Lines.
A-c Hoist Control.
Robots vs. the Manpower Situation.
Pitch as an Open Hearth Fuel.
Fuel Oil Systems.
Round Table Discussion on Burning the Lighter Oil in the Open Hearth.
Application and Results of Open Hearth Control.
Colloidal Fuel.
Application of Pulverized Coal to Metallurgical Furnaces.
Developments in Boiler Feed Water Conditioning.
Design and Operation of Single Stand Plate Mills.
Bar Mill Arrangements and Pass Design.
Rolls for the Billet Mill.
Developing a Practical Safety Program.
Building Safety into the Plant.
The Responsibility for Safety.
Centralized Lubrication for Blast Furnaces.
Lubrication of Non-Metallic Bearings.
Round Table Discussion on Selected Lubrication Topics.
Prevention of Corrosion in Water Systems.
Distribution Systems for Oxygen and Acetylene.
Chain and Chain Repairs.

# Blueprints of Victory now flow from Boards which conceived America's Industrial Leadership




To design engineers, accustomed to overcoming mechanical obstacles in their stride, the Axis was just another problem for them to lick.

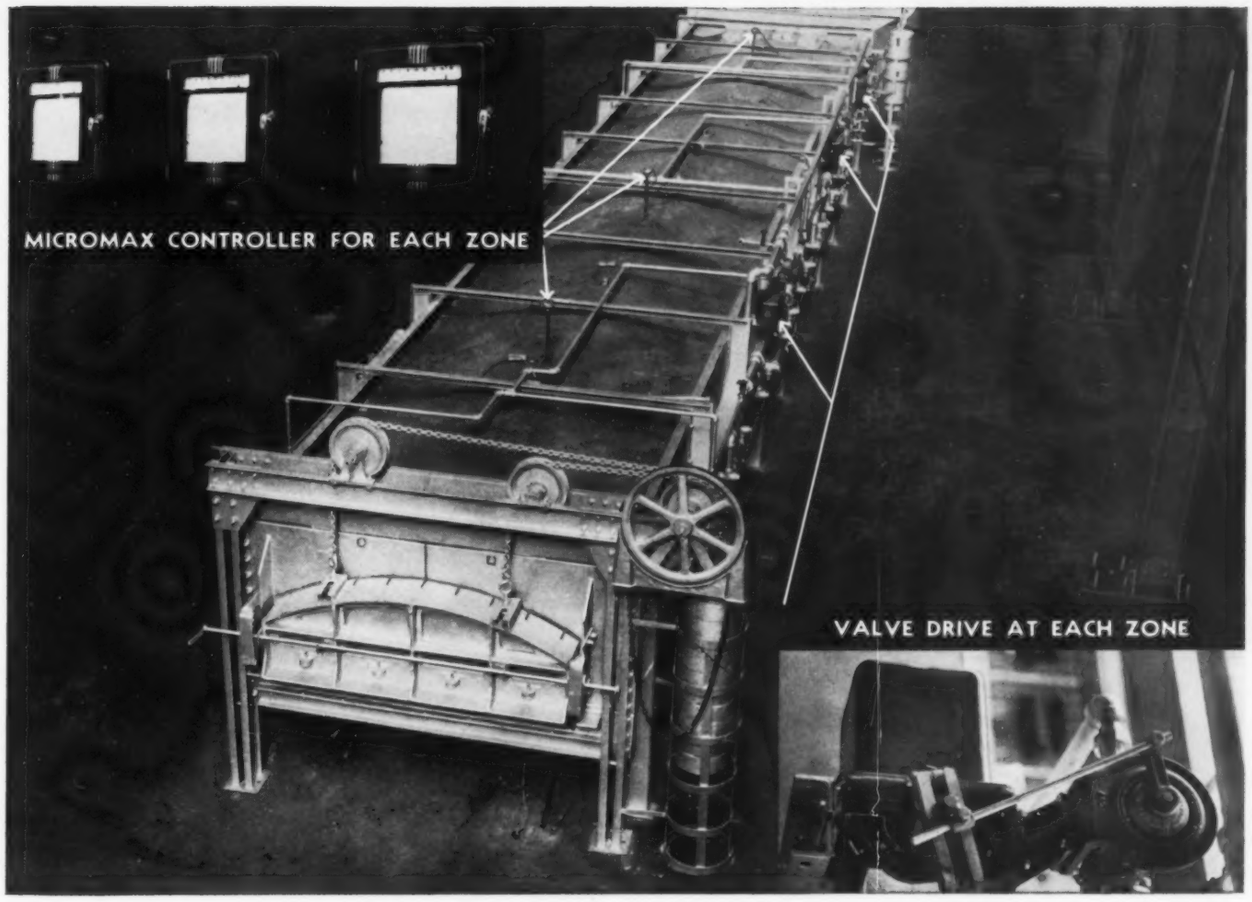
So they reached into their bag of tricks...the old American "know-how"...and came up with a thousand nightmares for the Axis dream.

And in designing these mighty weapons they naturally called on one of their chief stocks in trade—dependable Hyatt Roller Bearings, to help them in the job.

For that reason, you'll find Hyatt Roller Bearings built into the tools of fighting as well as farming, into tanks as well as trucks, into ships as well as machine shops, into warplanes as well as war workers' cars... carrying on their uninterrupted fight against friction and wear, making possible better design and, of course, the better performance which goes with it.

Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.

## HYATT ROLLER BEARINGS




Gas-fired three-zone wire-patenting furnace, equipped with Micromax Electric Control for holding each zone at exactly the specified temperature.

# OUTPUT OF COLD-DRAWN WIRE Is Speeded by Micromax Control Pyrometers

The furnace shown above has a vital war-time job — it is used for patenting, or specially-annealing, the Laclede Steel Company's hot-rolled rod, in preparation for the process of cold-drawing, which follows.

Patenting is an operation in which there's no such thing as too-close temperature control; the closer the control, the smoother and faster the drawing proceeds, and the longer the expensive drawing-dies can last.

Knowing this so well, Laclede's engineers picked Micromax Pyrometers to regulate the patenting temperature — to hold it as steadily on the mark as engineering skill and science will permit. And that's very close — so close that the Micromax chart records are sometimes almost ruler-straight for hours at a stretch.

If you could keep one eye on the Controller and the other on its fuel valve, you'd see how this evenness of regulation is maintained. You'd see the valve's position-pointer shift a bit toward the open or close position; yet the motion of the Controller's detecting mechanism might be so small you couldn't see it at first. There might be another valve-motion, or several more, before you could see that the pyrometer's record had been nudged ever so slightly out of line, and nudged back again as the change in fuel supply brought the temperature back to the control point.

That's what we call micro-responsiveness; the ability to act — correctly — when something tries to upset temperature. If the upsetting factor is small (a change in wind direction, perhaps), the correction is prompt but small. But if the upset is big, as when the furnace load is changed, the correction is both big and fast. Regardless of size, it's always in proportion, to hold temperature in the narrow path needed for high production of war goods.

If you have a furnace — whether for wire, or for cement, castings or anything else — on which you want highly dependable temperature control, tell us and we'll gladly try to help. Or, if you just want a Micromax catalog, ask for N-00A, "Micromax Electric Control."

Jrl Ad N-33A-626(2)

ARMY NAVY *V depends on me!*

A slogan for all Americans

LEEDS & NORTHRUP COMPANY, 4942 STENTON AVE., PHILA., PA.

LEEDS & NORTHRUP

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

Load is distributed over a wide area — not concentrated in a few points. That makes sense to me.

The load rides on a film of oil, under pressure between two highly finished surfaces.

The load-carrying ability of a Morgoil Bearing does not decrease as the speed of rotation is increased, or the direction reversed.

Morgoils are used on hot or cold mills of all sizes; billet, merchant, rod, strip, sheet . . .

# MORGOIL BEARINGS

*ride on a film of oil*

R-113

## MORGAN CONSTRUCTION COMPANY • WORCESTER, MASS.

# *Pennsylvania*
# PUTS ON THE PRESSURE
## . . . to Give Your Transformers POSITIVE PROTECTION against short circuits

All helical and pancake coils pre-compressed under pressures greater than short circuit stresses encountered in service.

The ability of the coils to maintain their shapes under the prescribed pressures definitely guarantees that the transformers will withstand short circuits.

Here are the fundamental principles used by PENNSYLVANIA in building transformers to withstand short circuits.

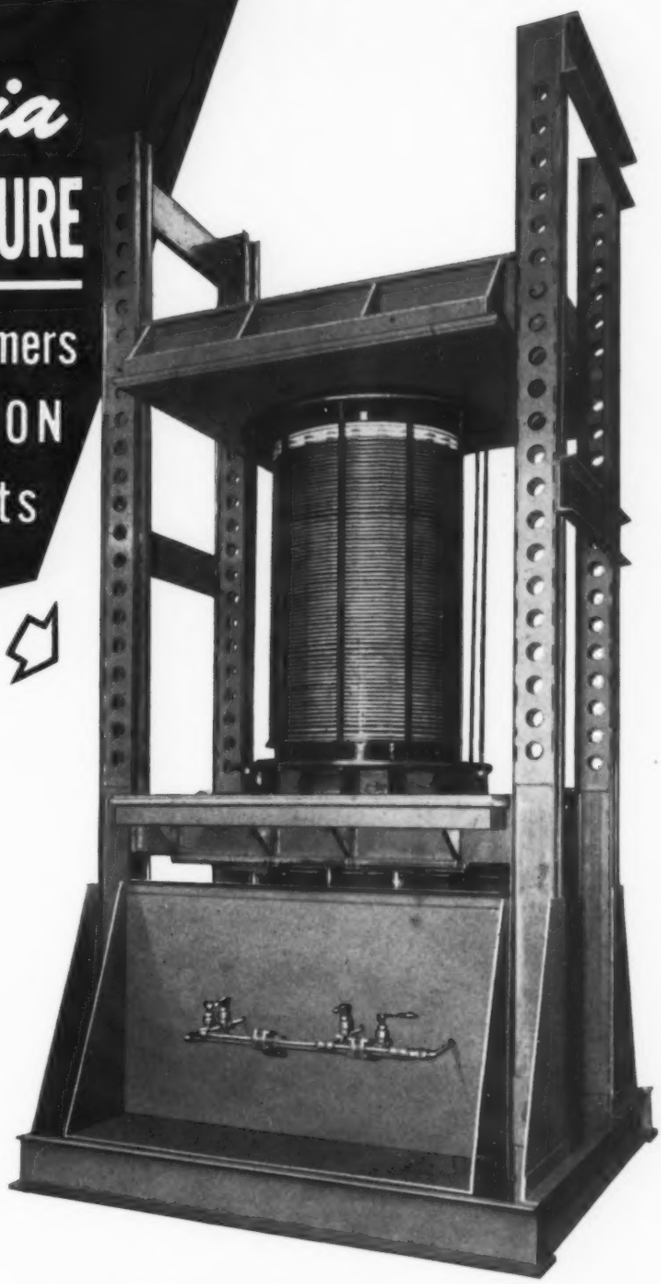
**1 DRYING** The coils and all insulation must be dried sufficiently to make sure that no shrinkage will take place when the transformer is in operation or is under a short circuit.

**2 PRE-COMPRESSING** The dry coils must be pre-compressed to such an extent that no further compression can take place under the most severe short circuit. This definitely precludes any possibility of the coil stack moving or distorting under short circuit.

**3 TREATING** After drying and pre-compressing, the coils must be treated in such a manner that they are self-supporting and will maintain their pre-compressed and pre-shrunk shapes when mounted on the core.

**4 SUPPORTING** The final step is to provide sufficiently strong supports at the top and bottom of the group of coils to keep the coils in their pre-compressed shapes.

★ ★ ★ ★ ★



5000 Kva coil under 125,000 lbs. pressure. This hydraulic press capable of applying pressures up to 600,000 lbs.

*Pennsylvania* TRANSFORMERS

**Pennsylvania TRANSFORMER COMPANY**

PITTSBURGH, PENNSYLVANIA

# WITH BLOOM LONG-FLAME BURNERS

## YOU CAN CONVERT FROM OIL TO GAS . . . FROM GAS TO OIL INSTANTLY!

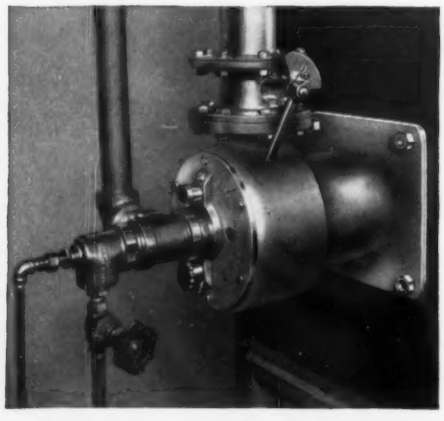
## NO DELAY
## NO SHUTDOWNS
## SAME HEATING RESULTS

Fuel shortages emphasize the service-proved advantages of BLOOM LONG-FLAME BURNERS—greater efficiency, uniform heating results, instant fuel change-over.

Hundreds of installations in all types of furnaces—billet heating, annealing, forging, heat treating, normalizing, ingot heating—have shown that Bloom engineering plus Bloom equipment increases furnace output, reduces fuel consumption, improves heating results.

Let Bloom help you modernize your furnaces for greater efficiency—better results.

The design and construction of Bloom LONG-FLAME Burners permits use of either gas or oil without delay for change over; and without altering heating conditions.



# BLOOM ENGINEERING COMPANY

**857 WEST NORTH AVENUE · PITTSBURGH, PA.**

*Keep 'em all flying*

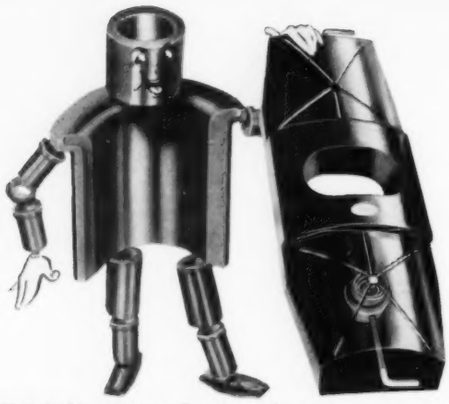
A copy of this United Nations poster, measuring 24"x 37" will be sent (while the supply lasts) to anyone who requests it on a company letterhead. Write to Koppers Company, Dept. A, Pittsburgh (19), Pa.

**KOPPERS**

THE INDUSTRY THAT SERVES ALL INDUSTRY

# Speed Output
## Avoid Maintenance
## Save Critical Metals

# GATKE BEARINGS



*GATKE Self-Alyn Slipper Bearings eliminate scoring and wear to companion surfaces. Stop deafening noises and troublesome grease-slinging. Absorb shock. Last ten times longer than bronze. Furnished to fit—require no machining. Made for all sizes and types of Universal Couplings.*

Long before Pearl Harbor GATKE Bearings were effecting multiple benefits of priceless value on countless Steel and Brass Mill applications.

Today they are replacing critical metals with greatly improved results on a tremendous range of both water-lubricated and grease-lubricated applications.

There is no need to let bearing shortage or bearing problems impede your war production. GATKE has solved the impossible on numerous tough jobs. The extensive experience and specialized facilities developed thru years of pioneer effort are available in meeting your requirements.

For quickest results send detailed information on the application, or write for Catalog.

*Other*
**GATKE PRODUCTS**
Brake Lining
Clutch Facings
Friction Blocks
Silent Gears
Pump Valves
Piston Rings
Sheet Packings

**GATKE CORPORATION • 228 N. LaSalle St., CHICAGO**

**Gatke MOULDED FABRIC Bearings**

**For Roll Necks, Universal Couplings, Spindle Carriers, Table Rolls, Cranes, Acid Resisting Service, and Other Tough Jobs.**

# made to measure
## for your individual needs

● Every Birdsboro "Special" Roll is individually "tailored" to the job it must perform. They are not made to meet general or average conditions. Each is engineered to its specific job —its analysis and physicals carefully planned for its purposes. That is why Birdsboro "Special" Rolls have such an outstanding reputation for giving longer roll life, greater tonnages and more rolling accuracy. If *yours* is a roll problem, it will pay you to consult Birdsboro.

For blooming mills, billet mills, structural mills, bar mills, rolling mild, structural shell, gun barrel, seamless tube and special alloy steels. Also for 4-high strip mill back-up rolls.

**BIRDSBORO STEEL FOUNDRY & MACHINE COMPANY • BIRDSBORO, PENNSYLVANIA**

**BIRDSBORO**

**ROLLS**

## NEW EXPANSION STARTS PRODUCTION AT HOMESTEAD

▲ Operations of the new Defense Plant Corporation unit at Homestead Works of Carnegie-Illinois Steel Corporation began June 14th with the tapping of the first heat of open hearth steel. Composed of eleven oil-fired 225 ton basic open hearth furnaces with a total annual capacity of 1,494,000 tons of ingots, the plant, when completed, will produce ingots up to 250 tons in weight, slabs up to 62 in. wide, plates up to 150 in. wide, 60 ft long and 6 in. thick as well as large forgings. Still under construction are the 45 in. reversing slabbing mill with 20 soaking pits, the 160 in. plate mill with 4 heating furnaces, and the 7500 ton forging press, machine shop and heat-treating department.

The open hearth shop presents a well-planned layout, with wide, roomy charging floor and pouring pit. Scrap storage is provided by an additional adjacent bay on the charging side. Adjacent bays on the pouring side provide brick storage and mould preparation facilities. The furnaces are designed for simultaneous slag flushing from the front and back. Two 800-ton hot metal mixers are installed, and three 12 ton charging machines handle the 44 cu ft charging boxes. Ladle cranes are of 275 ton capacity. Particular attention has been given to the movement of materials, and a well designed system of bins, conveyors, elevators, etc., handle the limestone, ore and alloys.

The lowest yard level of the new plant is 5 ft above the record 1936 flood stage, and auxiliary pumps have been installed to protect equipment located below high water level.

**First unit to begin operations at the new plant at Homestead, the open hearth shop includes all features of modern design.**

## FOLLANSBEE INSTALLS NEW MERCHANT MILL

▲ Recognizing the urgent necessity of carrying further the production of alloy steels by the forging process, the Follansbee Steel Corporation is now installing a 14-inch roughing and a 12-inch finishing merchant mill for the rolling of alloy and tool steel rounds, squares, hexagons, octagons, and flats in sizes from ¾-inch to 3½ inches.

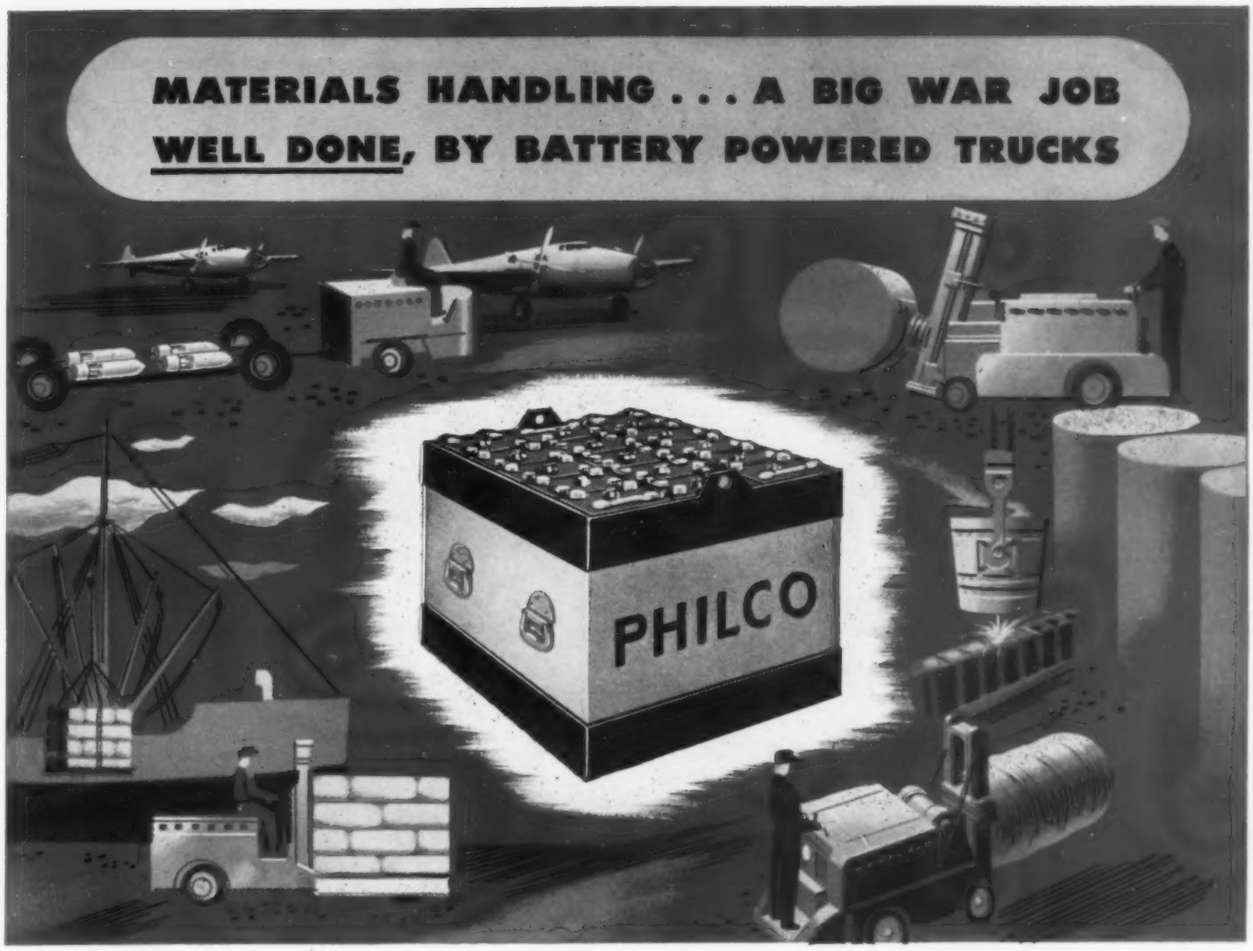
Four by four billets have been the minimum size produced at this plant in the past.

The production of alloy steels at the Follansbee Toronto, Ohio, plant is unusual in equipment and the methods of processing.

The company's small basic open hearth furnaces contribute largely to uniform chemical analyses. In the further processing of the steel, the entire production of the plant's ingot capacity is reduced by forging in place of rolling, as is the usual practice.

Forging the ingots assures that better physical properties are consistently produced in high grade alloys.

The company has an annual ingot capacity of more than 125,000 tons of high grade alloy steels.



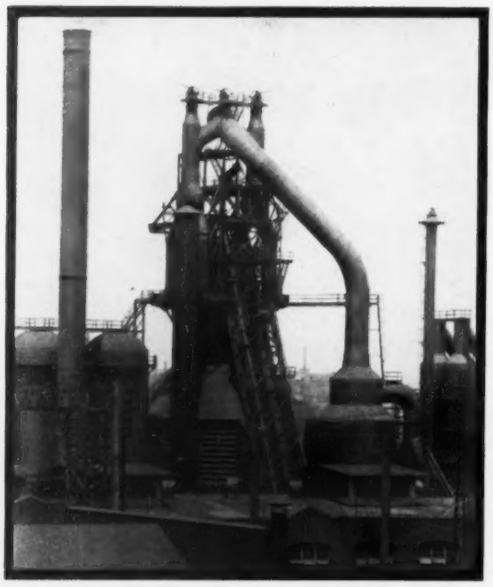

**POWERED BY PHILCO "XL" BATTERIES, TRUCKS HAUL 10% MORE MATERIALS**

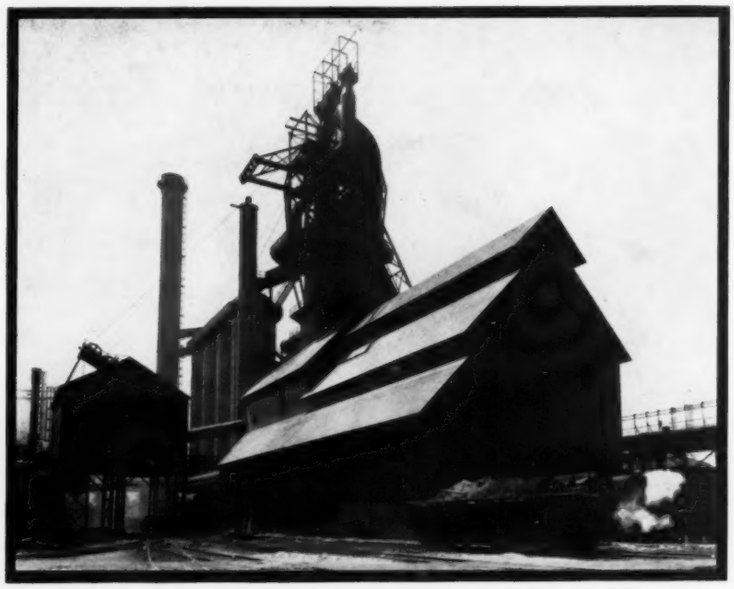
IN war plants everywhere, electric industrial trucks are assigned the tremendous job of moving materials *where* they're wanted, *when* they're wanted! And everywhere, too, these trucks are powered with Philco "XL" Batteries because with a Philco in the battery box, trucks do 10% more work! Philco "XL" Batteries are engineered to give you 10% extra capacity with extra wallop... longer life... better performance, too. For complete details, write for latest Philco Industrial Truck Battery Catalog.

**PHILCO CORPORATION**
STORAGE BATTERY DIVISION,
TRENTON, NEW JERSEY
*Sales Agents in all Industrial Centers*

*Replace with* **PHILCO** *Industrial Batteries*

## TWO NEW FURNACES TO MAKE THINGS HOTTER FOR HIROHITO





**The new blast furnace blown in July 1st at Bethlehem Steel Company's Bethlehem plant (left) is provided with three stoves; a turbo blower of 100,000 cfm of air capacity at 30 psi pressure; two 100,000 lb per hour boilers, combination coal and blast furnace gas fired; a new water intake and pumping station; and electric precipitation equipment for final cleaning of the blast furnace gas. The furnace is equipped with an elevator of 6000 lb capacity for taking men and equipment to the top. Another new furnace, 105 ft high and with a hearth diameter of 27 ft, was blown in recently at the Lackawanna plant (right). It has a total volume of 46,706 cu ft and a rated daily capacity of 1200 tons of pig iron. The installation also includes four stoves for preheating the air, each 122 ft high, and a new turbo blower having a capacity of 100,000 cfm of air at 30 psi. A new battery of 76 coke ovens, rated at 36,500 tons of coke per month, will also be put into operation within a few weeks. The hoisting and charging equipment is of latest design, with automatic control for maintaining the proper sequence in charging the different materials. The furnace is also equipped with an elevator of 6000 lb capacity, for taking men and equipment to the top platform. A 45-ton trolley at the furnace top is available to facilitate repairs of the superstructure.**

## CARRIER HANDLES PIPE OR RODS WITHOUT FLOOR MEN

▲ A new motor-driven pipe and rod carrier developed by the Cleveland Tramrail Division of The Cleveland Crane and Engineering Company, Wickliffe, Ohio, permits the cab operator to pick up 1,500 lb of stock in 12 foot lengths from the storage room, transport and set it in racks at fabricating machines, without any floor men.

Since the unit travels overhead its use eliminates the need of aisles and makes possible the saving of considerable floor area. In fact, the unit illustrated so reduced the need of floor space in an important war plant that 400 metal working machines could be installed and operated efficiently in a space slightly larger than that ordinarily required for 200 machines. Obviously, this in turn brought about a tremendous saving in building construction materials, so vital at this time, as well as a great saving in capital investment. This one unit keeps all of these fast-working machines supplied with stock.

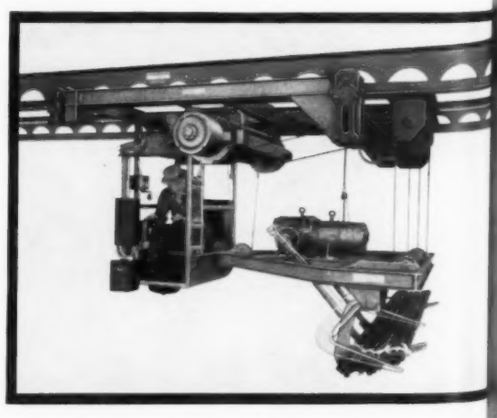
An outstanding feature of this equipment is the safety with which loads can be swiftly moved above machines and men. Materials transported need not be in balance nor is it necessary for the operator to spend time in locating the center of gravity of the load. The pick-up fork assembly has a 3-point rope suspension from the carrier which gives it the necessary rigidity for handling loads that are far out of balance. Another factor in providing stability is the double overhead track system on which the carrier travels. This minimizes swing and aids in removing the danger of loads slipping and falling in transit.

Rod and pipe are handled by two forks which are tilted upward when loading or downward when unloading, by a motor-driven crank. The photograph illustrates the forks in both positions. A limit switch automatically stops the forks in the upward or holding position when the fork mechanism is not in operation.

The fork assembly can be raised or lowered as required. This unit has a lift of 8 feet but others can be furnished for lifts of 20 feet or more if required. The hoisting speed is 20 fpm. Carrier travel speed is 300 fpm.

Similar carriers can be supplied for loads of heavier capacity and materials of other lengths. It seems likely that equipment of similar design can be applied to advantage in many industries for the efficient handling of various items.

**Operating without floor men, this carrier will handle 1500 lb of stock in 12 ft lengths between storage and fabricating machines.**



## VERTICAL MOTOR SAVES FLOOR SPACE

▲ A new line of direct-current vertical motors ranging from 40 to 200 hp at 1750 rpm, and in equivalent ratings at other speeds, has been announced by the General Electric Company. The new motors, which are furnished for both constant and adjustable speeds, are designed for low-thrust, solid-shaft applications on pumps, machine tools, and marine underdeck auxiliaries. They are also desirable in cases where valuable floor space must be saved or the expense of gearing avoided.

The motors are of drip-proof, protected construction, providing complete protection from dripping liquids and falling objects. Convenient fittings on both the upper and lower bearings simplify lubrication, and provision for the escape of excessive grease reduces the possibility of over-lubrication. A special bearing housing prevents grease from entering the motor and damaging the commutator and the windings.

The cast-iron conduit box is roomy and can be arranged for bringing the leads in at the top, bottom, or either side. Two hand-hole covers, removable without the use of tools, permit quick and easy inspection of the commutator end brushes. The ring-type base has an accurately machined rabbet and jig-drilled mounting holes, thus assuring permanent alignment with the driven machine. Sturdy lifting lugs facilitate installation.

## SEVEN YEARS ON ONE FURNACE LINING

▲ Completely relined for the first time in seven years, No. 8 blast furnace at the South Chicago plant of Carnegie-Illinois Steel Corporation was placed in operation recently.

The furnace, one of the largest in the string of eleven at the South Chicago plant, was first blown in March 29, 1936 and, with the exception of minor mechanical repairs, had been in constant operation until shut down for relining on April 7. Its output of iron neared 3,000,000 tons during the seven-year period, a record-shattering performance in production for the Chicago district of Carnegie-Illinois, United States Steel Corporation subsidiary.


SCHLOEMANN
Motor-Rollers

SIMPLIFY TABLE CONSTRUCTION

Free access along both sides of "Motor-Roller" Tables is afforded by Schloemann's simplified table construction which also reduces operating and maintenance expenses.

"Motor-Roller" tables are rugged in design and dependable in performance. Use of line shafts, couplings, and gear reduction units is eliminated with the free turning shell which houses the driving motor.

Schloemann installations are specifically engineered and designed for your particular requirements.

DISTINCTIVE ADVANTAGES OF SCHLOEMANN MOTOR-ROLLERS

1. Simple mechanical and electrical design
2. Flexibility of operation
3. Dependable performance
4. Accessibility around tables
5. Low maintenance cost

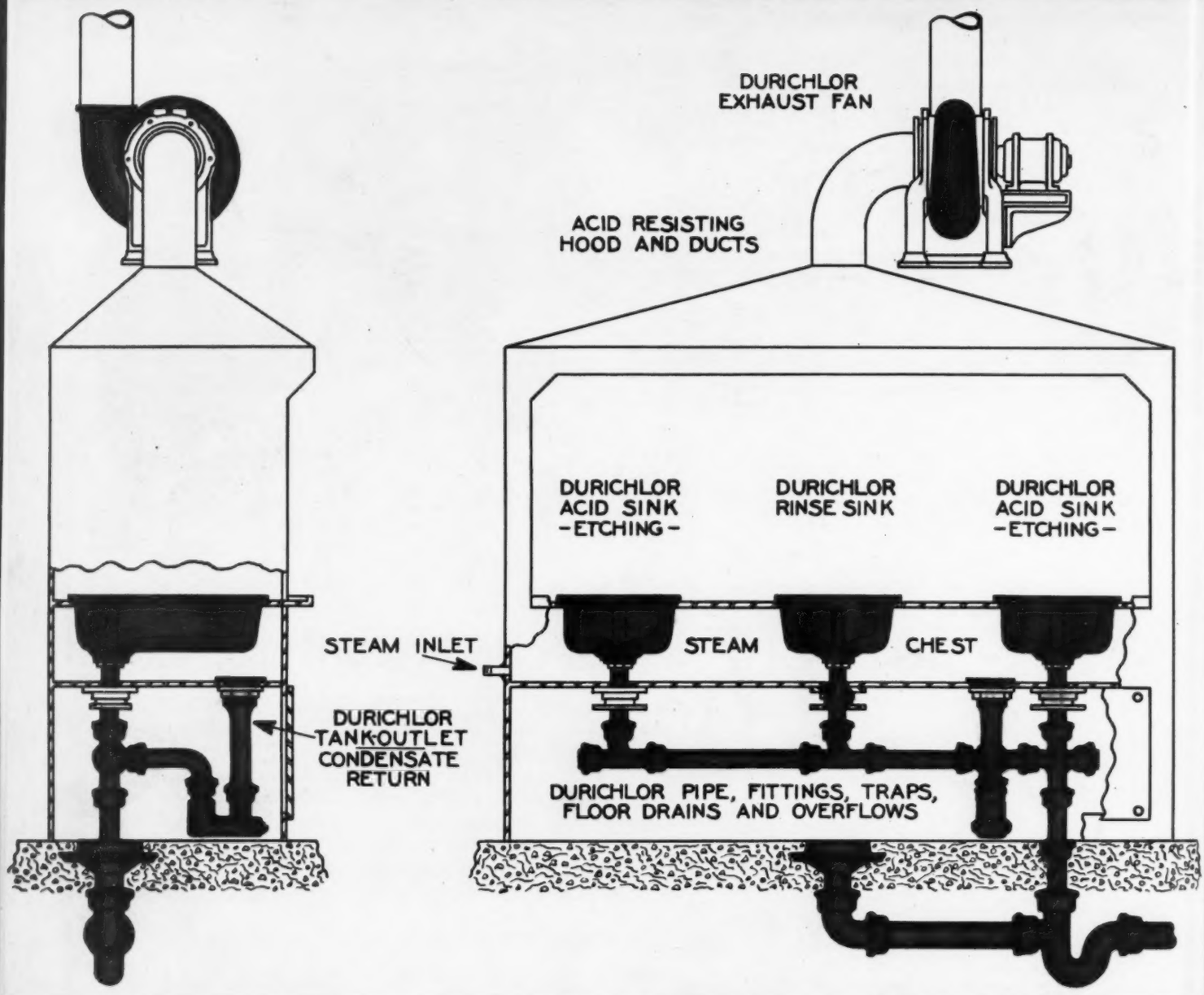
SCHLOEMANN
ENGINEERING CORPORATION

1102 EMPIRE BUILDING . . . . . PITTSBURGH, PA.

HYDRAULIC PRESSES • ROLLING MILL MACHINERY

# To Etch Samples of Steel

## FOR U·S· CONTRACTS




Many government contracts require test pickling of samples of steel billets. The muriatic acid used is of a strength and temperature highly corrosive to the equipment.

Durichlor equipment stands the gaff.

Because the corrosive fumes rapidly deteriorate ordinary equipment, some steel mills do not attempt to etch samples in their regular metallurgical laboratory.

Above is shown a typical plant layout of Durichlor equipment in a separate pickling room or shed.

Durichlor sinks hold the acid and samples, and Durichlor drain pipe and fittings carry away the waste and Durichlor fans exhaust the fumes.

The advantages may be summarized as follows:

***1—Good working conditions***
***2—Minimum maintenance costs***
***3—Consistent etch results***
***4—Minimum acid consumption***

In addition, equipment of Duriron, Durichlor and Durimet is widely used for unloading acids, waste acid disposal, pickling, etc.

Let us consult with you on your acid-handling problems. It has been our business for 31 years.

ARMY E NAVY

DURIRON · DURICHLOR
CORROSION-RESISTING
DURCO
ALLOYS & EQUIPMENT
THE DURIRON CO. INC.
DAYTON, OHIO
DURIMET · DURCO STAINLESS STEELS

**THE DURIRON COMPANY, Inc.** **DAYTON, OHIO, U. S. A.**

# ELECTRONIC DEVICE "3C" *Applicationeered*

¶ "3C" Engineers are alert to the advantages of Electronics in electrical control problems.

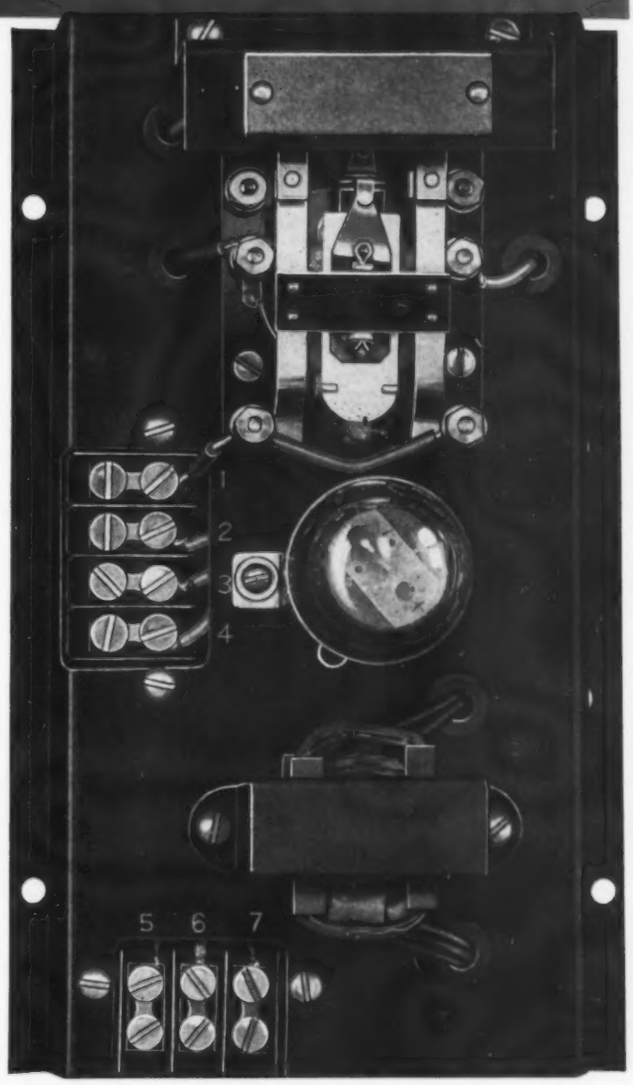
¶ Two Electronic devices—"3C" Bulletin 7313 Type ET Electronic Time Delay Relay, and "3C" Bulletin 7744 Weldmaster Timers for A. C. Resistance Welders—have been delivering excellent service in hundreds of war plants.

¶ Pictured is a special new Electronic Timer—simple in construction, and using only one tube.

¶ It is specially designed and built to time the travel of cross-feed on hydraulic feed in a Surface Grinder machine application.

¶ It has a time range of 1/10 to 1 second and is designed for 40 operations per minute, 24 hours a day—an extremely severe duty cycle.

¶ This Electronic Timer is built-in the machine—occupies minimum area—but allows plenty of wiring space. The Relay used is small but very rugged, to give millions of operations with minimum maintenance. All other devices used are not movable parts, are not affected by frequent operation, hence have exceptional trouble-free long life.




¶ This is a typical "3C" Application-engineered job, designed to do one operation only. It is not available in this particular form for any other application.

¶ Where the quantity of Electronic devices is large enough to warrant, "3C" Engineers will gladly work out a design to fit your particular needs.

CONTINUE TO ROLL WITH CLARK CONTROL

THE CLARK CONTROLLER CO.

1146 EAST 152ND ST. CLEVELAND, 10, OHIO

## TRUCK DESIGN SHOWS IMPROVED FEATURES

▲ The Baker industrial truck division of The Baker-Raulang Company, Cleveland, Ohio, announces a new 4000 lb capacity low-lift truck known as the type E-2, which was designed to give longer hours of uninterrupted operation and to provide greater safety of operation through better vision.

This truck is built on a 66 in. wheelbase and the overall length, including the operator's guard, is 123¾ in. This permits right angle turns in aisles 67 in. wide.

The battery box has been increased in size from 27 x 36⅝ in. to 32 x 39½ in., providing space for enough additional battery capacity so that the truck may be operated continuously on the longer shifts which the war emergency makes necessary. Thus it is not necessary, under most conditions, to stop during a working shift to change batteries.

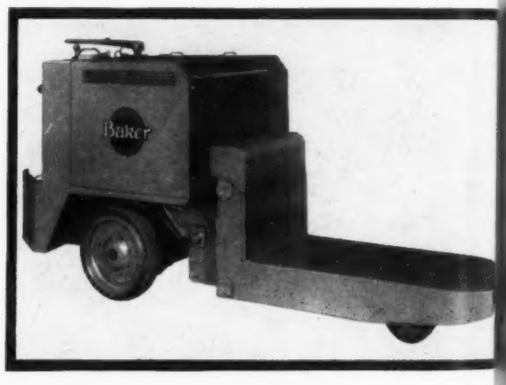
The front top corner of the battery compartment has been chamfered to aid vision and operators find that they can accomplish more work in a given time because of this better visibility.

The cover on the battery compartment is of the sliding type and is equipped with handles in place of hand holes.

The operator's guard is built integral with the frame, providing greater strength, additional safety to the operator and better appearance. The right side forms a handy compartment for carrying towing chain, pinch bar or other tools.

All controls, together with lift motor and pump, are in a convenient control panel which provides easy maintenance. The travel brake which is located just below the control panel is adjusted by a single hex nut which is out in the open where it can be readily reached.

The alloy-steel trailing axle is firmly anchored to the frame and the wheels steer on anti-friction bearings. The frame is a box section to withstand twisting strains and minimize maintenance.




**This 4000 lb low lift truck gives longer uninterrupted operation with greater safety.**

This truck includes such standard Baker features as the Baker travel motor, designed specifically for industrial truck service, the Baker duplex compensating suspension which eliminates all sliding contacts between the power axle and frame and an improved hydraulic lift system, which provides positive control of hoisting and lowering.

For complete specifications and dimensions ask for Bulletin 1107-a.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IT SAVES IN MAN POWER because it eliminates the necessity of making calculations to determine air excess or deficiency—does away with lost time in making experimental adjustments.

It saves in fuel because it indicates instantly when there is an incorrect proportioning of air and fuel. It is an infallible guide to highest possible combustion efficiency.

It saves in material through producing greater uniformity in production methods, in minimizing spoilage, etc. It may be used for indicating not only the ratio of air flow to fuel flow—but the ratio between other functions such as pressure, draft, suction, temperature (up to 1000° F) speed in R.P.M. or inches per minute, position, level and others.

The cross-pointer feature is exclusive with the Hays Visio-Ratio Gage. It shows at a glance not only the amount of the two flows but the percentage of excess or deficiency existing between them.

The HAYS CORPORATION
COMBUSTION INSTRUMENTS
MICHIGAN CITY, INDIANA, U.S.A.

*Send for*
PUBLICATION 41-478
ON CENTRALIZED
CONTROL OF OPEN
HEARTH FURNACES

## WPB, LABOR, MANAGEMENT START DRIVE FOR MORE STEEL

▲ The results of one prong of the three-fold drive launched July 1 to obtain an extra 2,000,000 tons of steel in the last half of this year, are already apparent, according to steel plant engineers, who state that the "green light" given the steel expansion program is actually expediting completion of the various projects through better deliveries of component units of equipment.

The "Steel for Victory" drive, based on speeding up completion of new steel capacity, "sharing the steel" through better distribution of third and fourth quarter production, and increased production through the active cooperation of labor-management committees, got under way with an inspection tour of the Pittsburgh district steel plants by WPB chairman Donald M. Nelson, executive vice-chairman Charles E. Wilson, Hiland G. Batcheller, recently appointed vice-chairman in charge of WPB, and Phillip Murray, president of the United Steelworkers of America. Plants visited included the Homestead, Duquesne, Irvin and Edgar Thomson works of Carnegie-Illinois Steel Corporation, Monessen works of Pittsburgh Steel Company, Aliquippa works of Jones and Laughlin Steel Corporation, and the Brackenridge plant of Allegheny-Ludlum Steel Corporation.

Presiding at a dinner meeting of labor-management committees, Benjamin F. Fairless, president of the United States Steel Corporation, keynoted the occasion, stating: "What we saw today gives us faith that labor and management will meet the new production quota set by the government. This is the kind of a day that makes our enemies exceedingly unhappy."

Marring the harmony of the occasion was the shadow of the unsettled coal situation, to which Mr. Batcheller attributed a loss of 126,000 tons of steel production during the preceding week. Mr. Batcheller said, "In just one week, Jones and Laughlin's Pittsburgh works can proeuce enough steel to build a 45,000 ton battleship — but not without coal. In two weeks Carnegie-Illinois' Ohio works at Youngstown can produce enough steel for an aircraft carrier — but not without coal. In a month the Park works of Crucible Steel can make enough steel for a heavy cruiser — but not without coal. We need more steel, so that the war can be shortened."

Mr. Batcheller also asserted that there had already been some 400 work stoppages in the steel mills of the nation, but expressed the belief that these losses in production would cease.

Mr. Murray stated that the steelworkers union "happens to be a union which realizes all those God-given blessings are at stake in this war. That is why this union has given a no-strike pledge to its country. It also happens to be a union which will live up to that pledge."

Speaking briefly just before the meeting ended, Mr. Nelson said, "We go home confident that this job is in good hands . . . Down in Washington sometimes we seem to be a long way from where the real work is done. I almost feel sometimes as if it were out of the United States. It gives us a thrill to actually see your efforts to win on the production front."

Asked how he felt about the threat of mine walkouts to steel production, Mr. Nelson replied, "I cannot imagine any American doing anything that would interfere with steel production. It is so very vital to the war effort."

Simultaneous with the Pittsburgh tour, 600 regional WPB workers began the task of covering the steel fabricating plants over the nation in an effort to find idle steel inventories and to improve steel distribution in relation to actual needs.

## SPECIAL MARKING DEVICE FOR SHELLS

▲ To meet shell manufacturers' requirements for a versatile and practical shell marker, the M. E. Cunningham Company, has made available a dual purpose box type holder which is said to successfully meet the specialized requirements.

**B. F. Fairless, president of United States Steel Corporation greets Donald M. Nelson, War Production Board Chairman, at County Airport as WPB party arrives for two-day tour of Pittsburgh's "Victory Valley" steel plants. Others in photo are Charles E. Wilson, vice chairman of WPB, left; H. G. Batcheller, vice chairman of operations WPB, next to Mr. Fairless; and B. F. Jones, III, vice president of Jones and Laughlin Steel Corporation.**

# NORTH AMERICAN

## *Atmospheric Regulators for Air-Gas Ratio*

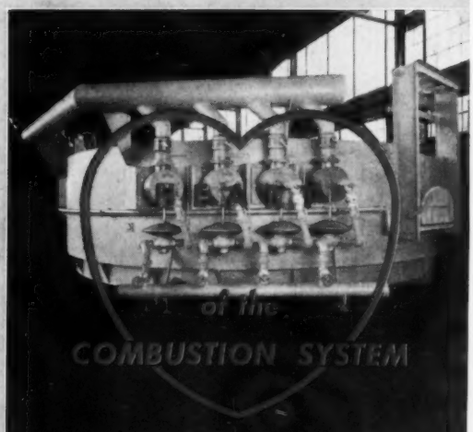
### Accurate Outlet Pressures

### Because—

In the NORTH AMERICAN Pressure System of fuel-air proportioning, the air valve controls the amount of fire. The fuel-air ratio remains constant because of the excellent operating accuracy of the NORTH AMERICAN Atmospheric Regulator. Any change, however small, in air pressure produces a proportional change in the flow of gas.

The NORTH AMERICAN Atmospheric Regulators are precision-built instruments—each one carefully checked and tested under actual operating conditions at the factory. A special flexible joint between valve and valve stem, special synthetic diaphragms, and a 1 to 1 ratio of the areas of the valve and small diaphragm are three additional reasons for the extreme accuracy of performance.

*"NORTH AMERICAN for COMBUSTION"*




Constant and correct gas-air ratio gives maximum heat for the amount of gas burned and uniform product resulting from constant furnace atmosphere.

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## reflect sound engineering and modern manufacturing methods

The skill and facilities Wagner has gained in 52 years of manufacturing quality electric motors are now being used to speed up Victory.

Wagner motors are built in a wide range of types and sizes with electrical and mechanical characteristics varied to meet the motor-drive requirements of all auxiliary equipment used in the steel industry.

If you need motors to help speed up war production, consult the nearest Wagner branch office.

M43-9A

**FIELD ENGINEERING SERVICE**

PITTSBURGH, CHICAGO, NEW YORK and all the rest of Wagner's 29 branches are manned by trained field engineers competent to solve your motor application problems.

**SEND FOR COMPLETE LITERATURE**

Bulletin MU-182 describes and illustrates the complete line of Wagner totally-enclosed fan-cooled motors, the ideal motors for all motor-driven equipment used in the steel industry. Write for your copy today.

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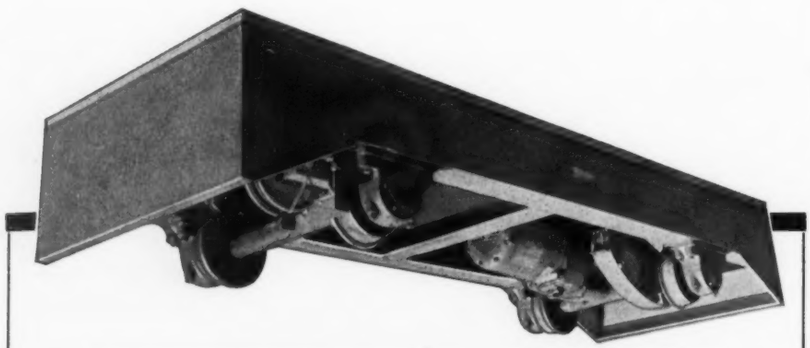
ELECTRICAL AND AUTOMOTIVE PRODUCTS

The holder is of special design for stamping identification marks on end and side of semi-finished 155-mm shell forgings in one operation. Unique guide plates level both type holders to assure clear, uniform markings. By eliminating the usual separate handling required for each marking, it is reported that marking costs have been reduced almost 50 per cent and, being manufactured of special "Safety" steel, users are assured of maximum service and safety by the elimination of spalling and mushrooming.

The M. E. Cunningham Company, likewise offers facilities to war production manufacturers who may need assistance in solving special marking problems. For further details, write this publication, or direct to M. E. Cunningham Company, 115 E. Carson Street, Pittsburgh, (19) Pa.

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Phillips Industrial cars are made to fit the job—perfectly! Motorized or manual, every construction detail is designed and engineered to provide the utmost in rugged strength and specific performance.

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MINE & INDUSTRIAL CARS—FABRICATED STEEL—IRON CASTINGS


## *New Literature*

▲ Metallizing Company of America, 1330 W. Congress Street, Chicago, Illinois has just published a bulletin folder describing new Mogul electric bonder, new time and money saving unit for preparing hardened metal surfaces for metallizing. Operates on 220 volts, 60 cycle line. Patented air-cooled electrode holder permits high speed bonding without fear of overheating, pre-hardening or distortion. Eliminates guesswork in preparation, eliminates carbon ring characteristic of other methods, eliminates the necessity of a lathe. Was developed originally to prepare heat treated surfaces for metallizing — works equally well on all metals. Practically as fast as rough threading. Folder gives specification, price and other money saving information.

▲ Presenting, in one volume, detailed information on the various processes of water conditioning and the types of equipment used, the Water Conditioning Handbook, published by The Permutit Company, should be of considerable interest to engineers and operators dealing with water problems. Exceptionally well illustrated with flow diagrams, sectional views, photographs, etc., the 459 pages, arranged in 22 chapters, include a description of the impurities which occur in raw waters, descriptions of the conditioning processes and equipment as applied to industrial and municipal use, methods of calculation, tabulated factors and data, etc. Also included is a discussion of the company's boiler blowdown equipment and gas analysis instruments. Many new developments in water conditioning equipment are discussed. The book is available from the Permutit Company, 330 West 42nd Street, New York, N. Y.

▲ The Askania Regulator Company has just published a new bulletin describing the application of automatic control equipment to soaking pit furnaces.

It describes completely the basic problems involved in soaking pit operation, the importance of correct temperature conditions, length of soaking period, effect of furnace atmosphere upon scale control, economical pit operation, combustion efficiency and all other problems which enter into today's steel production problems.

Typical diagrams show the application of control equipment to the soaking pit furnace.

In addition, a chart showing properties of typical steel mill gases is included. Heat balance and thermal efficiency is discussed and a heat balance approximation is also included.

A copy of bulletin No. 116 may be had by writing to Askania Regulator Company, 1603 S. Michigan Avenue, Chicago, Illinois.

▲ "Coke Oven Plant Construction and Development in 1942" is the subject of a leaflet just issued by Koppers Company, Engineering and Construction division. The pamphlet contains 12 pages, 11 photographs, and eight line drawings. The author is W. A. Leech, Jr., of the Koppers Company, Engineering and Construction division.

A summary of recent developments in the field of coke plant construction, the pamphlet lists improvements in design, cites certain new processes and gives construction figures for 1942.

Eleven coke plants were built and put into operation by Koppers during 1942. Those still under construction at the end of the year totaled 16. The total coal carbonization capacity of the 27 new plants is 11,661,000 tons per year.

▲ Boiler feed water conditioning and chemistry is a new publication issued by the Cochrane Corporation which deals with the most common processes used in feed water conditioning, and a discussion of such important factors as the characteristics of the hot process water softener, zeolite softener, removal of gases from boiler feed water, embrittlement and carry-over.

In addition to this there is a section devoted to interpretation of water analyses, conversion factors, chemical reactions, tables showing the formula, molecular weights, equivalent weights of all the chemicals commonly found in water conditioning practice.

If interested, write for publication 4008.

▲ The Brown Instrument Company, Wayne and Roberts Avenues, Philadelphia, has just issued a new bulletin entitled: Brown New-Matic Time-Pattern Controller.

In some industrial processes it is not only essential that temperature, pressure, flow or liquid level be controlled at a constant point but experience has proven that it is desirable to gradually increase temperature, pressure, etc., to a certain high value, hold at that value for a definite length of time and then decrease at a predetermined rate.

In such processes as these the Brown New-Matic Time-Pattern Controller provides the proper time scheduling which insures continuous maximum production of finished products of uniform quality.

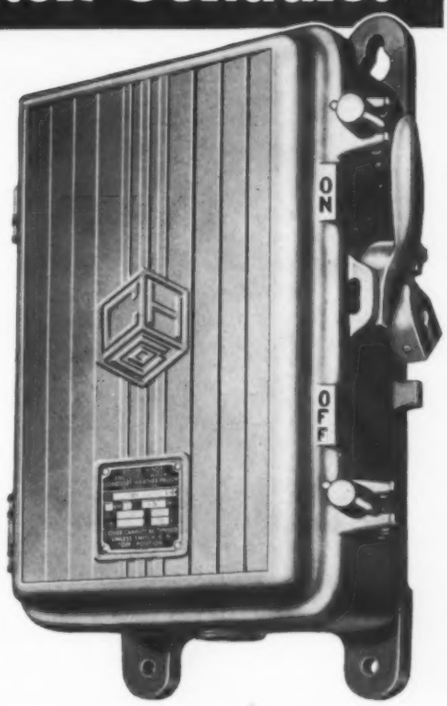
Bulletin 87-1 describes in detail the operating principle of this two-unit time-pattern controller: (1) The pattern transmitter and (2) the control instrument. The text is fully supplemented with diagrams and illustrations of installations.

A section is also devoted to a description of applications and the advantages to be obtained by Brown time-pattern control of manufacturing processes.

We will be glad to send a copy of this bulletin to any of your readers who may request it. Address the Brown Instrument Company, Wayne and Roberts Avenues, Philadelphia, Pennsylvania and ask for Bulletin No. 87-1.


**CROUSE-HINDS**

**Type WMK Enclosed Safety Switch Condulet**




- **Raintight.** For use in all indoor and outdoor non-hazardous locations. Also suitable for Class III and IV hazardous locations. *NEMA Types 3 and 5.*
- **Feraloy cases.** Strong and durable. Four sturdy mounting feet. Many possible conduit arrangements for both horizontal and vertical through feed.
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  1. Cover may be padlocked to prevent unauthorized entry.
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- **30, 60, 100, or 200-Ampere.** 1 to 50-H.P.
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CH753

# ITEMS OF INTEREST

**J. L. "Pete" Mauthe** has been appointed as vice president in charge of operations of The Youngstown Sheet and Tube Company to succeed the late William B. Gillies.

Mr. Mauthe's promotion came after 31 years in the iron and steel industry, eight of those years with The Youngstown Sheet and Tube Company and many others with U. S. Steel Corporation subsidiaries in various places.

After graduation from Pennsylvania State College, Mr. Mauthe went to the Duquesne works of the Carnegie Steel Company. Then in 1914, he went to work for National Tube Company at McKeesport, Pennsylvania, and four years later, became superintendent of blast furnaces for Midvale Steel Company at Coatesville, Pennsylvania. The next year, he went to the Illinois Steel Company, at Gary, Indiana, as assistant superintendent of the coke plant and then assistant superintendent of the blast furnaces. He next moved to Lorain, Ohio, as assistant superintendent of the National Tube Company's big plant.

He moved to Youngstown in 1935 as assistant superintendent of The Youngstown Sheet and Tube Company's Campbell plant and then became general superintendent of the district in 1937. Mr. Mauthe has been an active member of the Association of Iron and Steel Engineers for some years.

**Albert S. Glossbrenner** has been appointed as general superintendent of the Youngstown district of The Youngstown Sheet and Tube Company. Mr. Glossbrenner succeeds Mr. Mauthe, who was appointed vice president as of July 1.

Mr. Glossbrenner was superintendent of the Sheet and Tube Company's Brier Hill plant. After attending the University of Wisconsin he became interested in the steel industry. About 13 years ago he entered the employ of the old Illinois Steel Company, one of the predecessors of Carnegie-Illinois Steel Corporation, at the Gary, Indiana, tinplate plant. He then transferred to the same company's South Works at Chicago as assistant foreman. He came to Youngstown eight years ago as assistant superintendent of the hot strip mill, becoming superintendent about three years later. He was appointed as superintendent of the Brier Hill plant in September, 1942. Mr. Glossbrenner is an active member of the Association of Iron and Steel Engineers serving on the board of directors at the present time.

**Buford M. Stubblefield** has been appointed superintendent of the Brier Hill works of The Youngstown Sheet and Tube Company, succeeding A. S. Glossbrenner, who is now general superintendent of the Youngstown district plants.

Mr. Stubblefield was born in McLean, Illinois, September 13, 1892.

He graduated from the University of Illinois in 1915, and in the summer of the same year moved to Youngstown to take a position with The American Tar Products Company.

In 1916 he started to work for The Youngstown Sheet and Tube Company, at the Campbell works coke plant; in 1920 he became assistant superintendent of the coke plant, and in 1923 was made superintendent. In March 1929, he was made superintendent of the coke plant and blast furnaces at Campbell works.

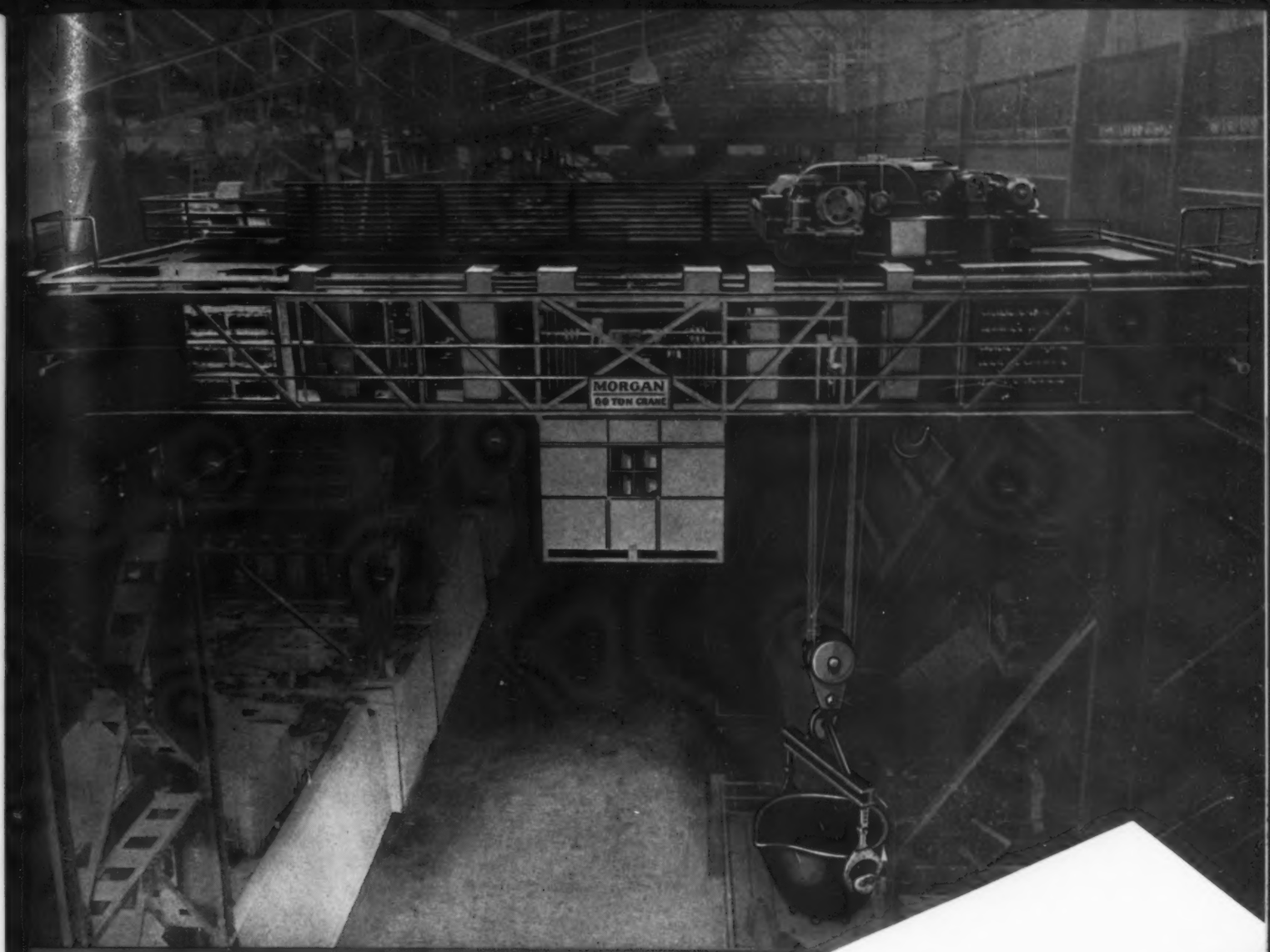
**Eugene B. Mapel** has been appointed manager of sales personnel and training of Carnegie-Illinois Steel Corporation.

Formerly assistant chief of the training division of this U. S. Steel subsidiary, Mr. Mapel has been active in the development of supervisory and employee training programs of the company for the past three years. Before coming to Pittsburgh in 1940, he was employed at the Gary Sheet and Tin Mill of Carnegie-Illinois at Gary, Indiana, for four years, serving as director of training immediately prior to his transfer here.

J. L. MAUTHE

A. S. GLOSSBRENNER

BUFORD M. STUBBLEFIELD




**MORGAN 60-TON 60′-0″**
**SPAN CONVERTER AISLE CRANE**

BUILT BY **MORGAN** *Engineering*

● Illustrated is a Morgan heavy duty mill type crane in a converter aisle. It is equipped with fabricated welded trolley and bridge trucks; hydraulic bridge brake and anti-friction bearings. Trolley is of the gear box type having two 60-ton identical hoists using plain motors with flexible couplings. An auxiliary girder is provided for supporting the center cage. As a safety feature, special relays are incorporated in the control circuit to limit the torque of the hoist motors when "pulling collars." On such crane equipment for copper smelter service, the stability of Morgan Engineering has long been well established.

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**William J. McMillen,** formerly assistant manager of roll sales at Mackintosh-Hemphill Company, has been appointed manager of production and manufacturing for the company.

Mr. McMillen entered the employ of Mackintosh-Hemphill 26 years ago as an assistant in the physical testing laboratory, worked his way up through the production department and was made assistant manager of roll sales in 1939. It was announced that despite the responsibility of Mr. McMillen's new duties as chief of the company's production, now completely converted to war work, he will continue to serve his old rolling mill roll customers as he has in the past.

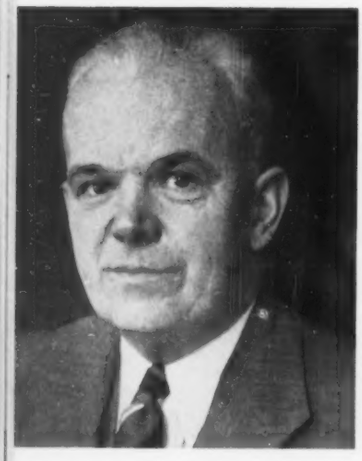
WILLIAM J. McMILLEN

**J. Guy Griffith,** president of the J. Guy Griffith Company, Union Trust Building, Pittsburgh, Pennsylvania, has been appointed Pittsburgh representative of The Wapakoneta Machine Company succeeding the late Jos. E. Fawell. He will direct the sales of the company's line of machine knives, circular slitters, and shear blades in western Pennsylvania. Mr. Griffith was formerly assistant plant engineer of the New Kensington plant of the United States Aluminum Company and continued in that capacity until 1925 when he organized his own company and engaged in a specialized engineering service and equipment sales, serving the steel, coal, and aluminum industries.

J. GUY GRIFFITH

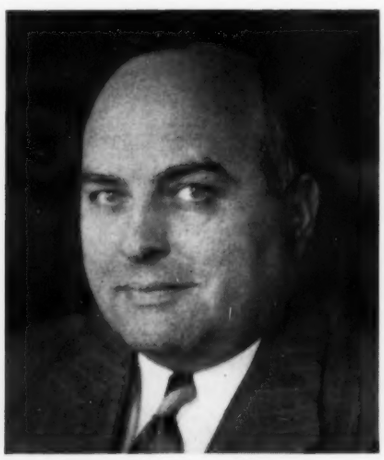
The Pittsburgh Rolls Division of the Blaw-Knox Company has announced the appointment of **P. M. Fleming** as vice president in charge of sales and operations. Mr. Fleming formerly was vice president in charge of sales. **Ralph H. Scholl,** sales engineer, has been appointed manager of sales; **S. Clifford Elms,** chief engineer, has been appointed general superintendent; and **W. H. White,** general superintendent, has been appointed metallurgical engineer in charge of research and new developments.

P. M. FLEMING



RALPH H. SCHOLL

S. CLIFFORD ELMS



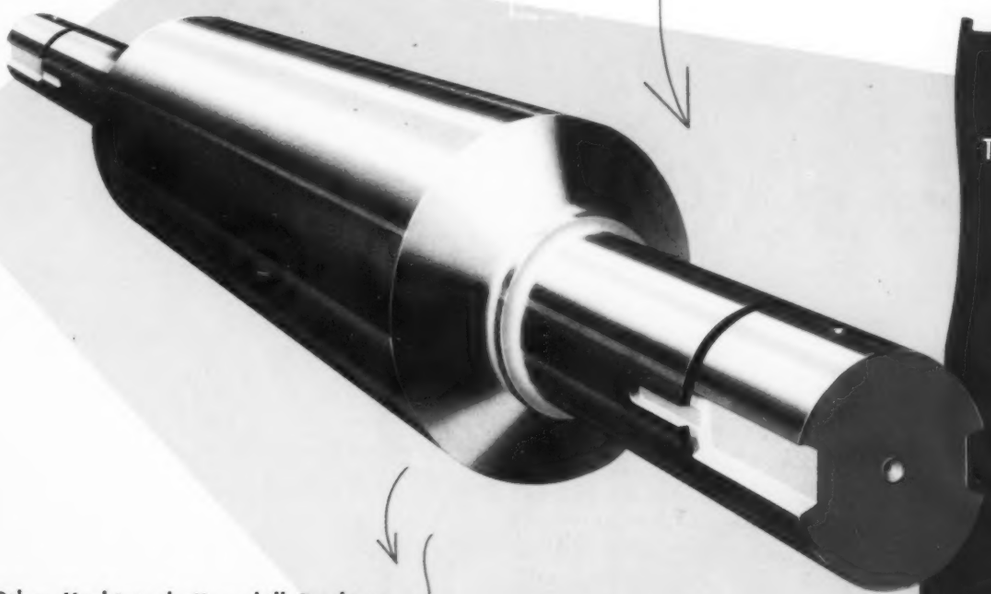
W. H. WHITE

Ol' Red Wabbler says:

# "Nironite D Work Rolls in 4-high single stand and tandem cold mills *give better finish . . . save roll dollars"*

M-H Nironite D Work Rolls for 4-high single stand and tandem cold mills have attained their greatest success in replacing forged and hardened alloy steel rolls, because they have greater resistance to indentation. This means better surface finish for the cold rolled product and a reduction in cost, because M-H Nironite D Rolls stay in the stands longer between roll grinds. These rolls also have a greater hardness penetration and thus can be used down to scrap diameter without being rehardened.

You can get better surface finishes and save roll dollars at the same time. Specify M-H Nironite D Work Rolls for single and tandem cold mills.



The rolls with the red wabblers

They roll more tons per grind

**Other Mackintosh-Hemphill Products:**

Rolling Machinery . . . Shape Straighteners . . . Strip Coilers . . . Shears . . . Levellers . . . Pinions . . . Special Equipment . . . Iron-Steel Castings . . . The NEW Abramsen Straightener . . . Improved Johnston Patented Corrugated Cinder Pots and Supports.

**MACKINTOSH-HEMPHILL COMPANY • Pittsburgh and Midland, Pa.**

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## Rockbestos Permanent Insulation Insures Long-Lived Performance

Rockbestos A.V.C. Power Cable illustrated*, and similarly insulated Motor Lead Cable (Underwriters' and Nat. Elec. Code, Type AVA) has a maximum operating temperature rating of 110° C. (230° F.) and this permanently insulated construction.

**1.** The conductor is perfectly and permanently centered in helically applied insulation that stays put and will not migrate or flow.

**2.** Felted asbestos insulation that withstands conductor-heating overloads and won't burn even when exposed to copper-melting arcs.

**3.** Lubricated varnished cambric for high dielectric strength and high moisture resistance, protected from heat, flame and oxidation by two felted asbestos walls.

**4.** Outer felted asbestos wall which serves as a heat-barrier against high ambient temperature.

**5.** A tough, rugged asbestos braid, resistant to heat, flame, moisture, oil, grease and corrosive fumes.

**One of 122 different wires and cables developed for severe operating conditions.*

Dampness, humidity and moisture raises hell with wires in electrical circuits that run around steel mill furnaces, finishing stands, soaking pits, boilers, steam tunnels, etc. It rots the insulation, causes shorts, and often ties up important production through wire-failure. You can guard your circuits against this hazard by wiring with Rockbestos A.V.C.—the wire that has ample moisture resistance and, in addition, provides heatproof and fireproof protection. Designed for high temperature locations, *permanently insulated* Rockbestos A.V.C. resists heat, flame, moisture, oil, grease and corrosive fumes. It won't bake brittle, crack, bloom, rot or swell. Prevent wire-failure in your "hot" locations with Rockbestos A.V.C.

When inquiring or ordering, please furnish CMP certification and allotment number with delivery month. For recommendations write nearest branch office or: Rockbestos Products Corporation, 901 Nicoll St., New Haven, Conn.

**ROCKBESTOS A.V.C.**

***The Wire with Permanent Insulation***

***FOR VICTORY ★ Invest in United States War Bonds ★***

NEW YORK, BUFFALO, CLEVELAND, CHICAGO, PITTSBURGH, ST. LOUIS, LOS ANGELES, SAN FRANCISCO, SEATTLE, PORTLAND, ORE.

**Warren D. Anderson,** for over five years a member of the engineering staff of Norma-Hoffman Bearings Corporation, Stamford, Connecticut, has been made assistant to chief engineer for the firm.

**David F. Austin,** Pittsburgh, Pennsylvania, has resigned as assistant director for production in the steel division of the War Production Board and has resumed his duties as vice president of the Carnegie-Illinois Steel Corporation.

Coming to Washington in February 1942 as consultant to the chief of the iron and steel branch, Mr. Austin served at various times as acting chief, deputy chief and assistant chief of the iron and steel branch, and assistant director for production of the steel division. Prior to his service with the WPB, Mr. Austin had served more than 25 years in various capacities with the United States Steel Corporation. The Carnegie-Illinois Company has now recalled him to Pittsburgh because of its urgent need for his services.

**C. B. Cook,** has been appointed vice president in charge of advertising, sales promotion and export sales of the Elwell-Parker Electric Company. A director of the company since 1941, Mr. Cook has been identified with the company for the past 28 years. He is a member of the Industrial Truck Statistical Association's Market Development Committee.

C. B. COOK

A graduate of Rose Polytechnic Institute, "Brent" Cook continued his engineering education through the apprenticeship course at Bullock Works of the Allis-Chalmers Manufacturing Company, becoming a member of its sales force in Cleveland in 1907. From 1908 to 1912, he was manager of the Toledo Office of Allis-Chalmers; and from 1912 to 1914 he was Ohio and Michigan district manager for Stevens-Duryea Company. In 1914 Mr. Cook became affiliated with the Elwell-Parker Electric Company to organize one of the first departments of sales-promotion ever to be established by an industrial manufacturer under that name. He also laid the foundation for Elwell-Parker's export activities and has directed them continuously since that time.


A formula for operating efficiency . .

MORGANITE BRUSHES

Withstanding the abnormal loads and peaks of tremendous war-time production, MORGANITE brushes assure good commutation and quiet operation even under long severe service. In motors, dynamotors and generators, MORGANITE brushes are doing their share dependably and unflinchingly.

Long-lived, and with minimum of energy loss, MORGANITE is available in a diversity of grades and bodies—each engineered to precise electrical and mechanical specifications.

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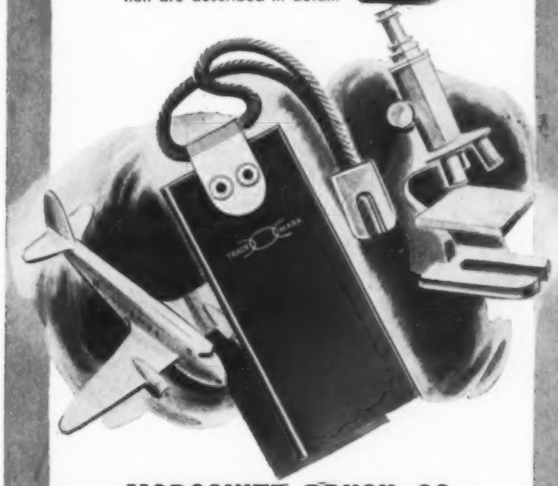
The MORGANITE 30-page informative booklet is available on request without obligation. The correct type, body, material and application are described in detail.



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INCORPORATED
LONG ISLAND CITY, NEW YORK

THE WAPAKONETA MACHINE CO.
*Incorporated 1891 — Wapakoneta, Ohio.*

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Plant Managers! Superintendents! Purchasing Agents! Production and Plant Engineers! Here's a book that will give you the answers to your marking problems. It contains hundreds of illustrations, with concise descriptions of Marking Devices for every Industrial Marking application. Yours for the asking . . . request a copy on your letterhead today!

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**G. V. Dutney,** who a few months ago was appointed assistant manager of the Johns-Manville industrial department, has in addition to his other responsibilities been named manager of the newly formed steel industry section of this department, according to L. A. Baldwin, vice-president.

Mr. Dutney has been associated with Johns-Manville for the past 23 years. After his graduation from Cornell University in 1910, he was employed by the Jones and Laughlin Steel Corporation until 1920, except for an interlude of 2 years spent in France as Captain in the Ordnance Department, U. S. Army.

In 1920, he joined Johns-Manville where he has since been in close contact with the development and sale of the industrial products of this company. He served in various sales and sales management positions in Pittsburgh, Cleveland, and New York. In 1935, he was made assistant manager in charge of all industrial products in the Philadelphia district, a position which he held until brought to general headquarters in New York in his present capacity.

C. H. WILLIAMS

**C. H. Williams** has been made chief engineer, Pittsburgh district, Carnegie-Illinois Steel Corporation. Mr. Williams was graduated from the University of Colorado, College of Engineering, in 1926, and was employed by the Jones and Laughlin Steel Corporation, South

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# "It's easy to handle ...it must be an Exide"

## New workers appreciate the simplicity of Exide Maintenance

INDUSTRIAL RECRUITS, like their more experienced fellows, are learning about the compact efficiency found in Exide Ironclad Batteries. Rugged construction and easy maintenance are important features of an Exide Ironclad. They shorten the training periods of new workers and help deliver surging power for a real War of Movement on the Home Front.

**STUDY THESE EASY MAINTENANCE RULES**

- Keep adding approved water at regular intervals. Most local water is safe. Ask us if yours is safe.
- Keep the top of the battery and battery container clean and dry at all times. This will assure maximum protection of the inner parts.
- Keep the battery fully charged—but avoid excessive over-charge. A storage battery will last longer when charged at its proper voltage.
- Record water additions, voltage and gravity readings. Don't trust your memory. Write down a complete record of your battery's life history. Compare readings.

If you wish more detailed information, or have a special battery problem, don't hesitate to write to Exide. We want you to get the long-life built into every Exide Battery. Ask for booklet Form 1982.

**Exide IRONCLAD BATTERIES**

**1** **HIGH POWER, MORE PRODUCTION:** An Exide Ironclad Battery delivers its power at high voltage to insure good hauling speeds. There's always a giant surge in reserve when an Exide powers your battery-propelled vehicles.

**2** **LONG LIFE, SAVES MATERIALS:** Every Exide is built to last, and saves vital materials by squeezing the last ounce of use out of the materials in it. When you buy an Exide you definitely ... Buy to Last and Save to Win!

**3** **EASY MAINTENANCE, SAVES LABOR:** Exides are kept charged by the simplest method ever devised. With the Exide Charge Control Unit there's nothing to do but connect the battery to the charging source and turn a knob.

THE ELECTRIC STORAGE BATTERY COMPANY, Philadelphia
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Side Works, Pittsburgh, as shear foreman in September of that year. In June, 1927, he was juniot engineer in the power engineering department of the National Tube Company, in the Pittsburgh plant. In April 1930, Mr. Williams joined the Carnegie Steel Company, Youngstown district, as junior engineer in the steam engineering department. He successively served as power and fuel engineer and assistant chief engineer of the Youngstown district. In August, 1940, he was transferred to the Pittsburgh office of the Carnegie-Illinois Steel Corporation as power and fuel engineer on the staff of the chief engineer. In December, 1940, he was appointed assistant chief engineer, Carnegie-Illinois Steel Corporation, Pittsburgh district.

**John D. Leitch** has been made chief engineer of The Electric Controller and Manufacturing Company.

A graduate of the University of Glasgow and recipient of a Ph.D. degree in physics from University of Toronto, Dr. Leitch has been with the Electric Controller and Manufacturing Company since 1937. Prior to, during and after schooling, he was associated for about 15 years with the mechanical engineerint and electrical engineering departments of the Steel Company of Canada with the exception of time-out of four winter periods for study in Scotland. He also did X-ray and radium research in connection with the Cancer program for the Ontario Government for 5 years prior to his connection with the Electric Controller and Manufacturing Company.

**Howard L. Dawson,** for the past three years chief engineer of the Pittsburgh District, Carnegie-Illinois Steel Corporation, has been appointed assistant chief engineer of the company to succeed the late L. C. Edgar.

After studying machine construction and metallurgy at the Carnegie Institute of Technology, Mr. Dawson entered the employ of Carnegie-Illinois in 1910 at the Isabella Furnaces. He was transferred to the Edgar Thomson Works of this U. S. Steel subsidiary two years later, working there as a draftsman, efficiency engineer, construction engineer and master mechanic before becoming superintendent of the maintenance department in 1933.

He was transferred to the Pittsburgh general offices of Carnegie-Illinois as engineer in charge of repairs, maintenance and lubrication in 1939, and the following year he was appointed to the post of chief engineer here.

Ohio Equipment Manufacturing Company, Cleveland, has moved to 1367 East Sixth Street, Cleveland, 14, Ohio. They are manufacturers' agents and promote the sale of materials handling equipment for intra-plant transportation and storage, representing such companies as the Yale and Towne Manufacturing Company, Philadelphia, on electric industrial trucks, hand lift trucks and skid platforms; the Powell Pressed Steel Company, Hubbard, Ohio, in connection with corrugated pressed steel skid platforms and boxes; Economy Engineering Company, Chicago, on portable lifters.


The most effective defense against leakage on all vital flow-lines in steel plants

*—for controlling gas, oil, residues, air and water*

*Sizes: ½" to 30".*

*—for all temperatures*

*—all pressures*

NORDSTROM *Lubricated* PLUG VALVES

Leaking valves are the saboteurs of production. Keep flow lines flowing by installing positive action, positive sealing Nordstrom Valves. Keep upkeep down.

Nordstroms meet every major valve need. Lubrication under pressure keeps these valves in prime condition, making them easy to turn, and also sealing the ports against leakage.

**MERCO NORDSTROM VALVE COMPANY** *A Subsidiary of Pittsburgh Equitable Meter Co.*

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# Obituaries

**Huntington B. Crouse,** president of the Crouse-Hinds Company, Syracuse, New York, died June 11. Born in Fayetteville, New York, 70 years ago, he was a pioneer in the manufacture of electrical equipment.

HUNTINGTON B. CROUSE

In 1897 Mr. Crouse with J. L. Hinds established the Crouse-Hinds Company, and under their management built one of the largest manufacturing concerns of electrical appliances in the country.

Mr. Crouse was president of the National Electrical Manufacturers Association in 1928. He was one of the national industrial leaders to second the Swope plan of standard trade practices, an important move toward unemployment insurance and other benefits for employees.

**Lieutenant-Colonel Edward M. Levine, U. S. A.,** was killed in North Africa June 15th. Graduating from Washington State College in mechanical engineering in 1929, Colonel Levine was employed by the Cincinnati Milling Machine Company until 1933. For the next three years he served as a captain in the Corps of Engineers, U. S. A. In 1936 he became field engineer in the Pittsburgh district for Cincinnati Milling Machine and Cincinnati Grinders, Inc., serving in this capacity until 1941 when he re-entered the army.

**Edward M. "Cap" Wise,** Pittsburgh district manager of the Alliance Machine Company for the past 21 years, died June 26th after a brief illness.

Born and educated in Pittsburgh, Mr. Wise was formerly connected with the Westinghouse Electric and Manufacturing Company and was a member of the Veteran Association of that company. He was a member of the Association of Iron and Steel Engineers, and was a familiar figure around Association functions.

**William B. Gillies,** vice-president in charge of operations of The Youngstown Sheet and Tube Company, died June 20 in Youngstown.

Mr. Gillies began his career in the steel industry immediately after his graduation from Cornell University as foreman for Illinois Steel Company and served in this capacity from 1904 to 1907. From 1907 to 1913 he


NATIONAL ROLLS

The Never Ending Science

REVIEW of the progress in the quality of rolls generally over the last decades reveals roll metallurgy as a constant, constructive, advancing science; an art given and known only to the few.

Improvements in scrap selection, in the moulder's art, in the heating, the blending of alloys, the timed casting, and finally, the machining and finishing, are now delivering a product of a degree of service unknown only a few years ago.

NATIONAL ROLLS are carefully developed, each as a separate study, to deliver ample and accurate output sufficient to inspire the confidence of those using them.

We build into each NATIONAL ROLL all of the skill and legend of the industry at our command.

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All Grades of Plain and Iron Alloy Rolls—Both Chill and Grain Types
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The MOST PUMP in least Weight & Space

The DeLaval-IMO pump for fuel oil and "lube" oil services is distinguished by compactness and simplicity. There are only three working parts, which are in complete hydraulic and rotational balance and which propel the oil without pulsation, like a piston moving steadily forward. There are no valves, no gears, no cams and no reciprocating parts. The one packing is under suction pressure only and is easily accessible. Any quantity of oil is delivered against any pressure.

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IMO PUMP DIVISION
of the De Laval Steam Turbine Company, Trenton, N. J.



Specialists for over a generation in

OIL IMMERSED MOTOR CONTROL

ROWAN CONTROL
THE ROWAN CONTROLLER CO., BALTIMORE, MD.

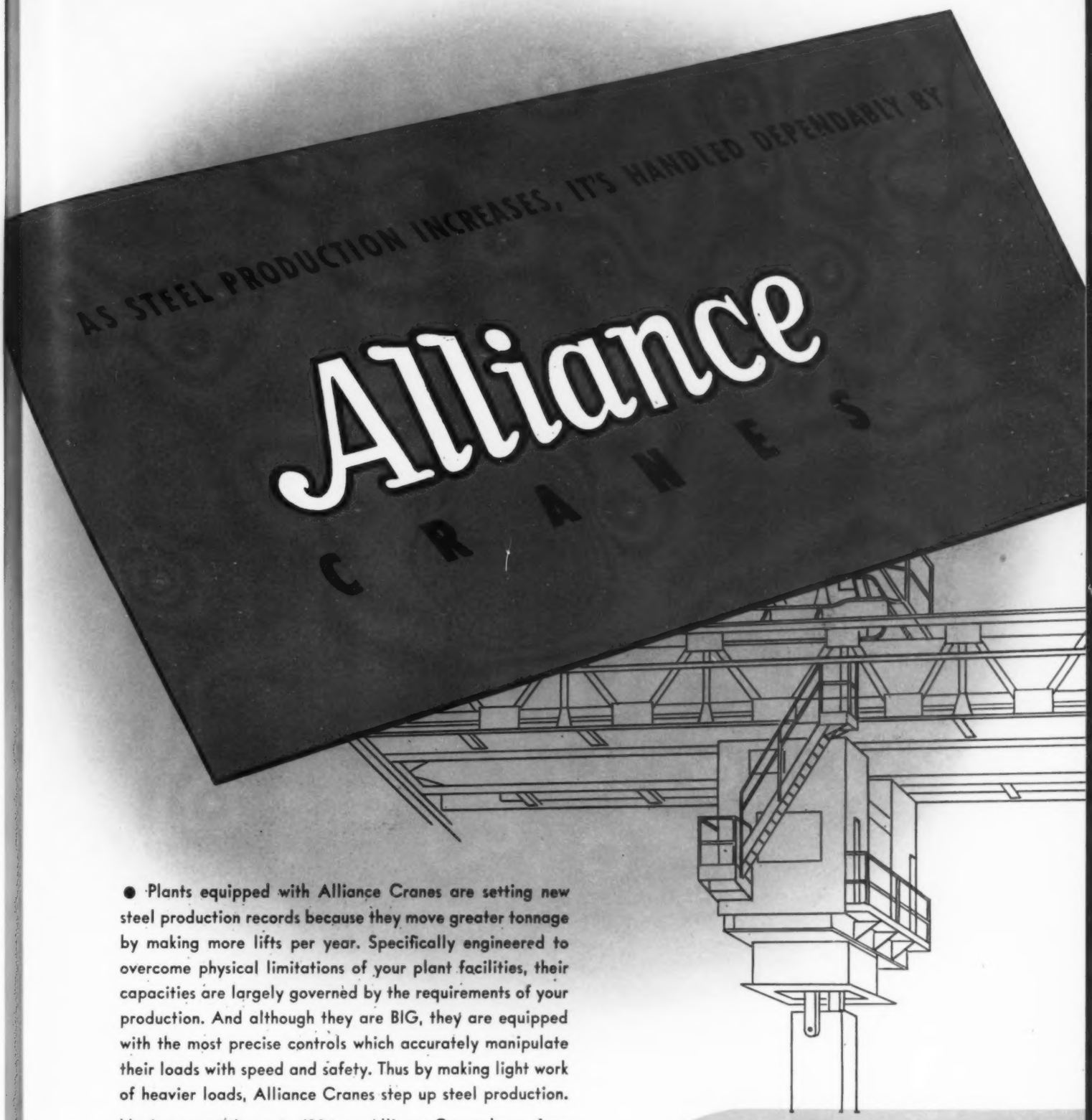

was superintendent of the Bessemer department at the South Works of the Illinois Steel Company; from 1913 to 1917 he was superintendent of the Bessemer and rail mill departments of the same organization; from 1917 to 1921 he was the assistant general superintendent of the Mark Manufacturing Company of Chicago; from

WILLIAM B. GILLIES

1921 to 1923 he was general superintendent of the Steel and Tube Company of America; from 1923 to 1929 he was district manager of The Youngstown Sheet and Tube Company's Chicago district plants; from 1929 to 1933 he was assistant vice-president in charge of operations of The Youngstown Sheet and Tube Company and was located in Youngstown; from 1933 until his death he was vice-president in charge of operations.

F. E. LEAHY

**Frank E. Leahy,** fuel engineer for Youngstown Sheet and Tube Company, died July 3rd following a brief illness. Mr. Leahy graduated in mechanical engineering from Stevens Institute of Technology, and was one of the pioneers in combustion engineering, serving in this field with Carnegie Steel Company and National Tube Company until joining Sheet and Tube in 1927. He was very active in Association affairs, helping to organize the combustion division and contributing extensively to Association proceedings.




● Plants equipped with Alliance Cranes are setting new steel production records because they move greater tonnage by making more lifts per year. Specifically engineered to overcome physical limitations of your plant facilities, their capacities are largely governed by the requirements of your production. And although they are BIG, they are equipped with the most precise controls which accurately manipulate their loads with speed and safety. Thus by making light work of heavier loads, Alliance Cranes step up steel production.

Having capacities up to 430 tons, Alliance Cranes have given dependable service throughout the 42 years they have been manufactured. Their rugged construction, plus many patented operating features, will help you avoid shutdowns. Consult Alliance Engineers for handling your steel from the scrap pit to the finished product . . . They know how it should be done.

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FORGING MANIPULATORS
SOAKING PIT CRANES
STRIPPER CRANES
SLAB AND BILLET CHARGING MACHINES
OPEN HEARTH CHARGING MACHINES

**THE ALLIANCE MACHINE COMPANY • ALLIANCE, OHIO**

# What's your welding "KNOW-HOW" on these two metals?

## Wrought Iron

**1. Q.** What filler metal should be used?

**A.** In welding wrought iron best results are gained by using a standard mild steel filler metal or a rod containing small percentages of alloying elements. These rods are preferred over wrought iron filler metal where welds of high corrosion resistance are required.

**2. Q.** When the metal first appears molten, is it ready to weld?

**A.** Fusion of the slag content in wrought iron at about 2100°F gives the metal a deceptive molten appearance. However this is far below the proper welding heat of 2700°–2770°F. Therefore the flame or arc should be applied until a puddle of molten metal appears. This molten puddle should be maintained while filler metal is applied.

## Galvanized Steel

**1. Q.** How may galvanized steel be welded to have a minimum burning away of the galvanized coating?

**A.** To obtain this result galvanized steel should be oxyacetylene braze-welded with Airco No. 22 manganese-bronze rod, and Airco Hi-Test Brazing Flux. Fusion welding by flame or arc with steel welding rods or electrodes is likely to destroy the galvanizing near the weld and expose the base metal to corrosive attack.

**2. Q.** How should flux be used?

**A.** Airco Hi-Test Brazing Flux should be applied to both sides of galvanized parts, and to inside and outside of pipe and fittings. The flux application stops zinc fuming and thus preserves the galvanized coating under the welding heat.

**HERE'S YOUR "KNOW HOW" GUIDE FOR WELDING MANY METALS**

Procedures for welding most commercial metals are given in the Airco manual, "Welding Procedures". Welding novices and even experts will find much valuable information both on methods and materials recommended for best results. Send for your free copy by filling out and mailing the attached coupon..

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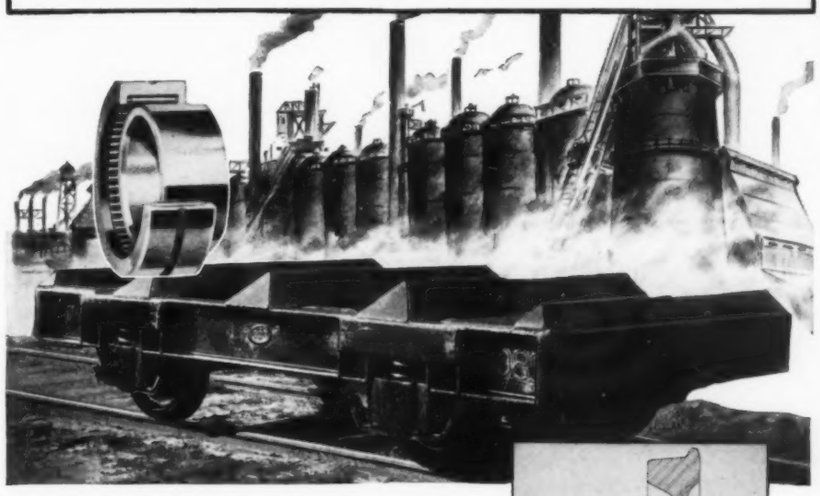
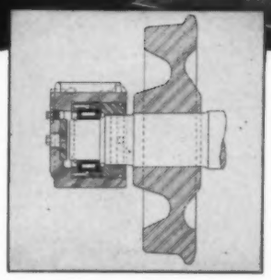
IDLE CYLINDERS ARE PRODUCTION SLACKERS: KEEP 'EM ROLLING FOR VICTORY!

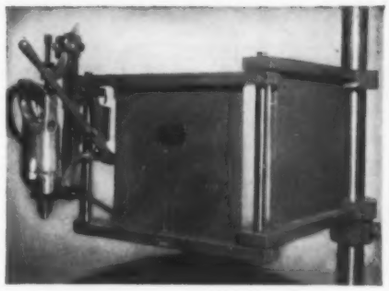
# IN THE NEWS
## WITH TORRINGTON—BANTAM



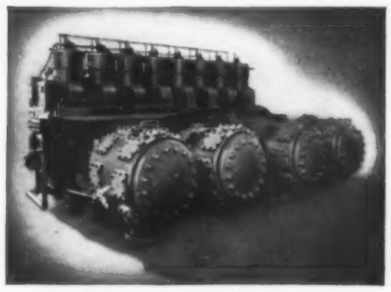
**25 TONS OF CHARGE** are carried by buggies like this one, to feed the steel furnaces at the Kaiser plant on the West Coast. Constructed by the American Car and Foundry Company, these cars employ Needle Bearings Type NCS on the axles, as shown in drawing. Efficient service is contributed by the low friction coefficient, high load capacity and effective lubrication method of these bearings.



**FARM PLANTING** is made easier by this heavy-duty "Rototiller" which prepares seed beds all ready for planting in a single operation. Needle Rollers Type LN are assembled into economical, high-capacity anti-friction bearings on both ends of the connecting rods and on the wheels of this progressively designed unit. The rollers at the wrist pin end are projected beyond the connecting rod in such a way that they are constantly lubricated by a fog of oil from the crankcase. At the lower end, oil catches are used.



**DRILL PRESS OPERATION** was obtained in this Black & Decker portable drill through the development of a radial arm attachment to speed production in an airplane factory. Compact arm design and flexibility over a wide radius of operation are combined with anti-friction performance through the use of NCS Needle Bearings—a typical case where the small size and high load capacity of these bearings have proven important advantages.



**NO TIME FOR SHUTDOWNS** in the oil industry—and these sturdy two-cycle, gas-engine-driven compressors built by Clark Bros. Co. Inc., are designed for service 24 hours a day. Type NCS Bearings are used in the wrist pins of the scavenging pump crossheads where the high load capacity of these bearings assures smooth, reliable performance. A catalog containing complete data on our line of Needle Bearings will be gladly sent upon request. Just write for Bulletin E-104.

**NEEDLE BEARINGS FOR ALL PURPOSES,** as well as special and standard anti-friction bearings of every type, are available from one source through the combined facilities of Bantam and Torrington. Here, too, is experienced skill to serve you in the unbiased selection or design of bearings to meet any requirement. For the utmost satisfaction in the solution of *your* bearing problems, TURN TO BANTAM.

ARMY E NAVY

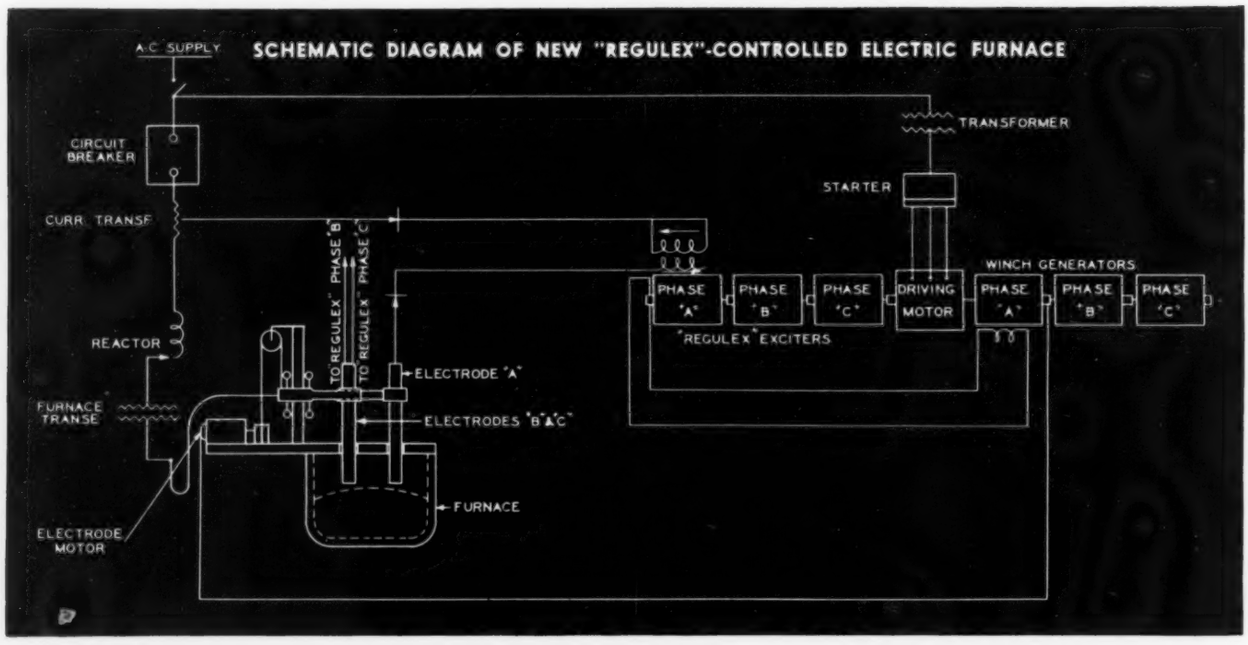
**TORRINGTON BEARINGS**

STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

THE TORRINGTON COMPANY · BANTAM BEARINGS DIVISION

SOUTH BEND, INDIANA

# NEW "REGULEX" exciter revolutionizes electric furnace control by producing electrode speeds proportional to deviation of controlled quantity from desired value. ☛ With no large resistance in circuit, maximum rated speed of electrode motors is available for automatic correction after a "cave-in". Electrode burning is minimized. ☛ Heavy starting surges, caused by throwing the 250 volt d-c motor across-the-line are done away with by variable voltage control. ☛ Arc furnace power and control are independent of d-c shop supply interruptions when desired. ☛ Regenerative braking action of the "Regulex" exciter unit stops electrode motors fast. ☛ Uses no contacts or motor line contactors.




NOTE IN WIRING DIAGRAM of "Regulex"-controlled, 3-phase electric arc furnace that each electrode winch motor is powered by an electrode generator, in turn controlled by its own "Regulex" exciter.

Individual "Regulex" units are quick-acting, move electrodes so that arc current is held proportional to arc voltage. Production is *stepped up!*

In one plant this smooth, fast-acting amplifying generator actually permitted *one or more extra "heats" per day* . . . on a furnace side-by-side with two identical units equipped with conventional control.

Amplifying characteristics of "Regulex" exciter are similar to those of the electronic tube — with important advantages in greater ruggedness and far longer life. "Regulex" exciters also perform an outstanding job in rolling mill motor control.

For complete information on the new "Regulex" exciter, call our district office near you. Or write ALLIS-CHALMERS, MILWAUKEE, WIS.

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**ALLIS-CHALMERS**

WE WORK FOR VICTORY WE PLAN FOR PEACE

# Use This Check List

**WHEN INSTALLING BRUSHES ON YOUR ELECTRICAL EQUIPMENT**

1. See that all terminals are securely fastened to the brush holder support.
2. Remove dirt and grit from brush holders.
3. Provide $\frac{1}{8}$" to $\frac{3}{16}$" clearance between commutator and nearest portion of brush support in reaction and box type brush holders. Less clearance is sometimes preferable on small motors.
4. Keep angular position of all brush holders uniform with respect to the commutator.
5. Check neutral point and space the brush arms equidistant about the commutator.
6. See that toes of all brushes on each arm are parallel with commutator segment.
7. To prevent streaking of commutator, stagger brushes in positive and negative pairs.
8. Seat new brushes on commutators and rings accurately with sandpaper or a brush seating stone.
9. Adjust brush spring pressure to conform with manufacturer's recommendation.

Care exercised in the installation, fitting and adjustment of brushes increases life, improves performance and eliminates many of the possible causes of interrupted service.

NATIONAL TRADE-MARK *Carbon, Graphite and Metal-Graphite* BRUSHES

"National" brushes are doing their full share of carrying the enormous load demanded by the Nation's war effort. Essential requirements must be met first. Every effort is being made to satisfy all demands for our brushes in the shortest possible time.

Proper maintenance is paramount in keeping your electrical equipment operating at full efficiency. Many valuable and time saving suggestions as well as details of operations mentioned in the above check list are included in this series of "Modern Pyramids" bulletins. Copies are available promptly upon request.

**NATIONAL CARBON COMPANY, INC.**

Unit of Union Carbide and Carbon Corporation

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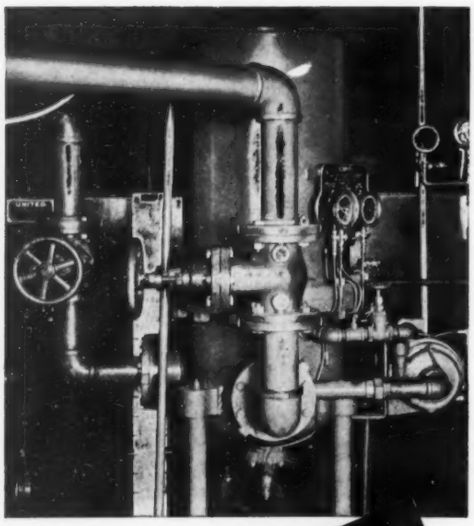
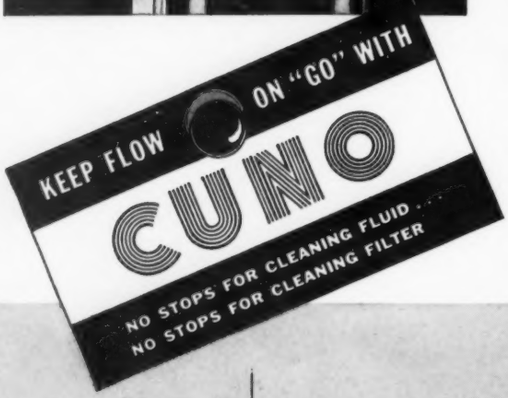
LET'S GO! U.S.A. KEEP 'EM FLYING!

THE WORD "NATIONAL" AND THE SYMBOL ARE REGISTERED TRADE-MARKS OF NATIONAL CARBON COMPANY, INC.

# Cuno Keeps Coolant Continuously Clean at Follansbee






Roll body coolant at Follansbee is kept continuously free from foreign solids by the Cuno Flo-Klean Filter, shown in the photograph at left.

Straining a coolant solution 94% water and 6% soluble mineral oil, this Cuno Flo-Klean is built to .006-inch spacing with free area of 75 sq. in. and has a capacity of 231 g.p.m. at a 3-lb. pressure drop, or of 347 g.p.m. at a 4-lb. pressure drop. Small steel particles and other dangerous suspended solids are separated from the coolant by this filter and removed from the system.

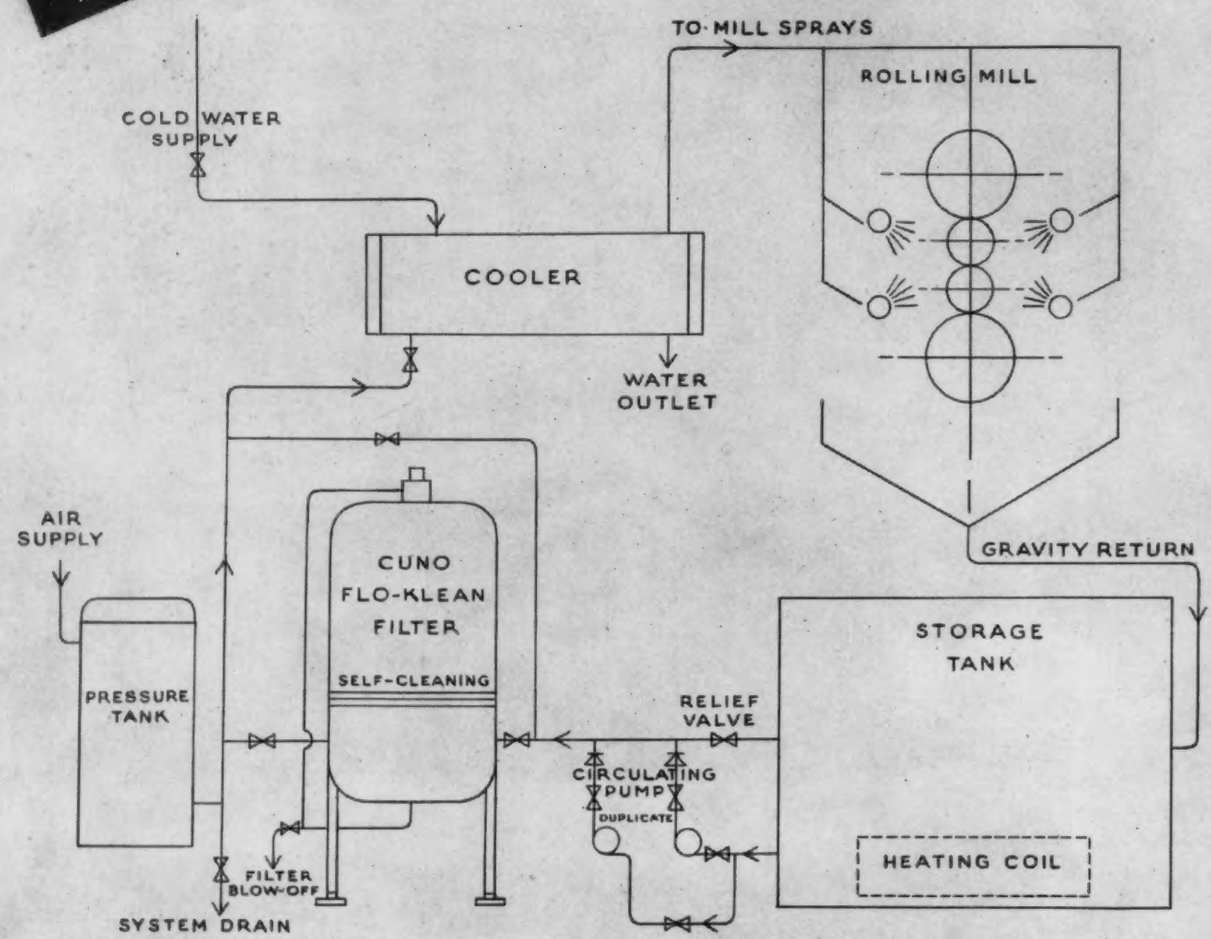
**Gives Water a Bath — Then Cleans Itself.** The Cuno Flo-Klean is a backwash type of filter, with filter element consisting of one or more wire-wound cylindrical cages. Fluid flows through slots between wires — all solids larger than slots are retained on outer surface. Backwash fluid, picked up at the outlet connection by a small booster pump and delivered to a slowly rotating nozzle, causes momentary reversal of flow at each section of the filter element, and thus dislodges adherent solids. No loss of fluid since all backwash is returned to the system. Accumulated solids are periodically drained through manually or mechanically operated blow-off valve; and floating sludge is simultaneously removed through a top blow-down.

**Ends 3 Dangers to Peak Production.** Cuno Flo-Klean filters prevent shutdown of fluid flow for filter-cleaning, especially where costly and space-consuming duplex installations are impractical. They provide a high degree of filtration, prevent abrasive particles from getting into the system to cause expensive damage or delays. And they do not need to be disassembled for cleaning —consequently do not expose the system to contamination during this operation.

**Two Types of Cuno Filters Available.** Cuno Auto-Kleans (disc-type) operate on edge filtration principle, handle full flow and are continuously cleanable (manually or automatically); for fuel and lube systems, as well as other industrial liquids.

Cuno Flo-Kleans (wire-wound) are designed especially for fluids of high abrasive content, i.e. descaling spray and roll body coolant systems.

For descriptions of newsworthy applications, write for free booklet, "Quick Facts". Cuno Engineering Corporation, 907 South Vine St., Meriden, Conn.



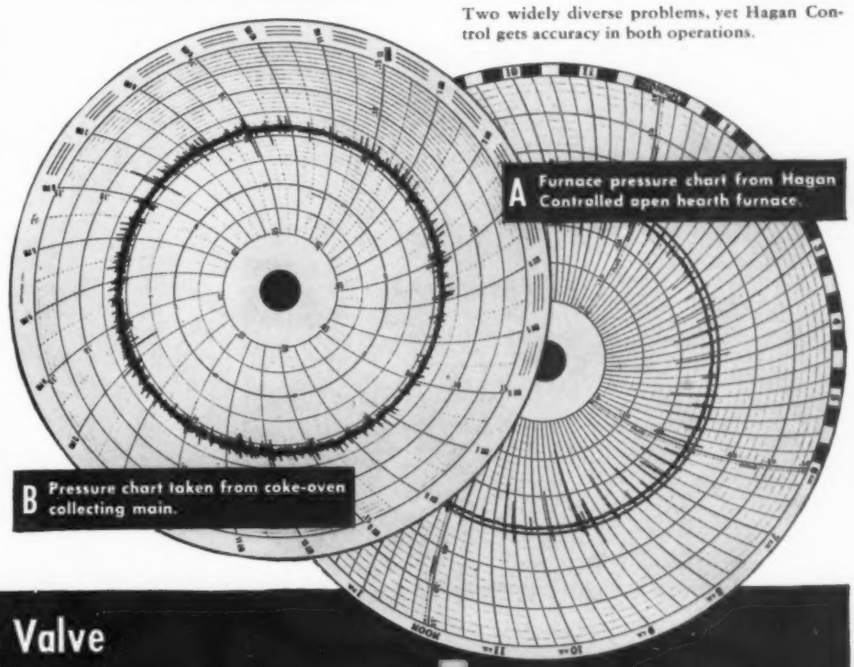
# Hagan Control—

## RELIABLE • STABLE • ACCURATE • FAST • POWERFUL

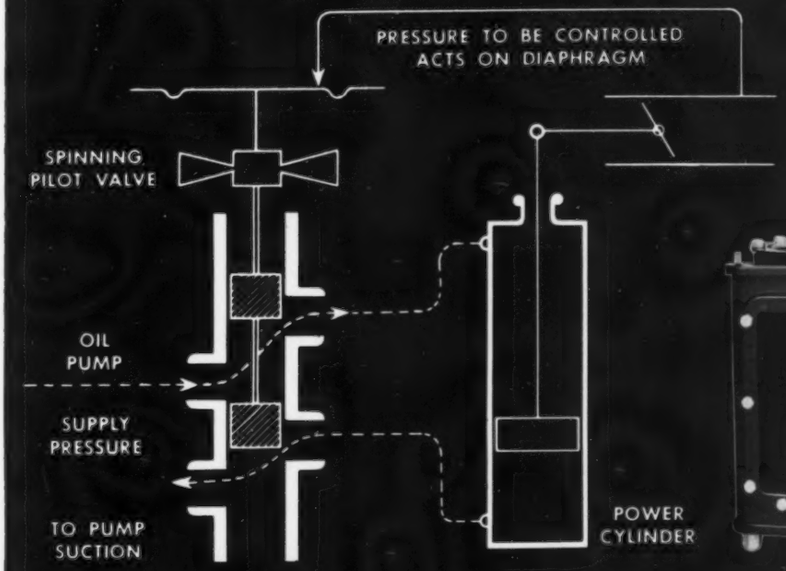
● The desirability of automatic control on metallurgical furnaces is generally accepted. To make sure you are getting the *best* control, however, the characteristics of the regulator chosen should be examined for performance under widely differing conditions of operation. *Not to be overlooked is the possibility of unexpectedly heavy resistance to movement in the valves and dampers to be controlled.*

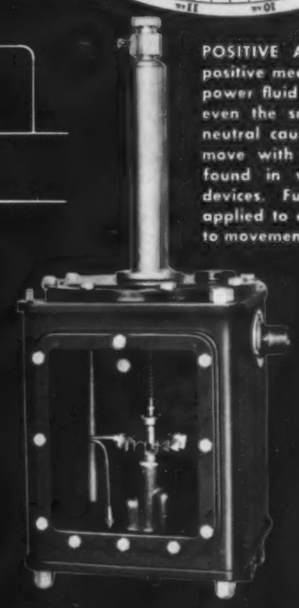
The Hagan spinning pilot valve responds *instantly* to the slightest change in the regulated quantity. What's more, it always applies *full* pump pressure (not partial pressure) to the operating piston. The result is immediate action of the power cylinder and quick return of the controlled pressure to standard. See charts for accuracy of control.

Two widely diverse problems, yet Hagan Control gets accuracy in both operations.


A Furnace pressure chart from Hagan Controlled open hearth furnace.
B Pressure chart taken from coke-oven collecting main.

### Hagan Spinning Pilot Valve



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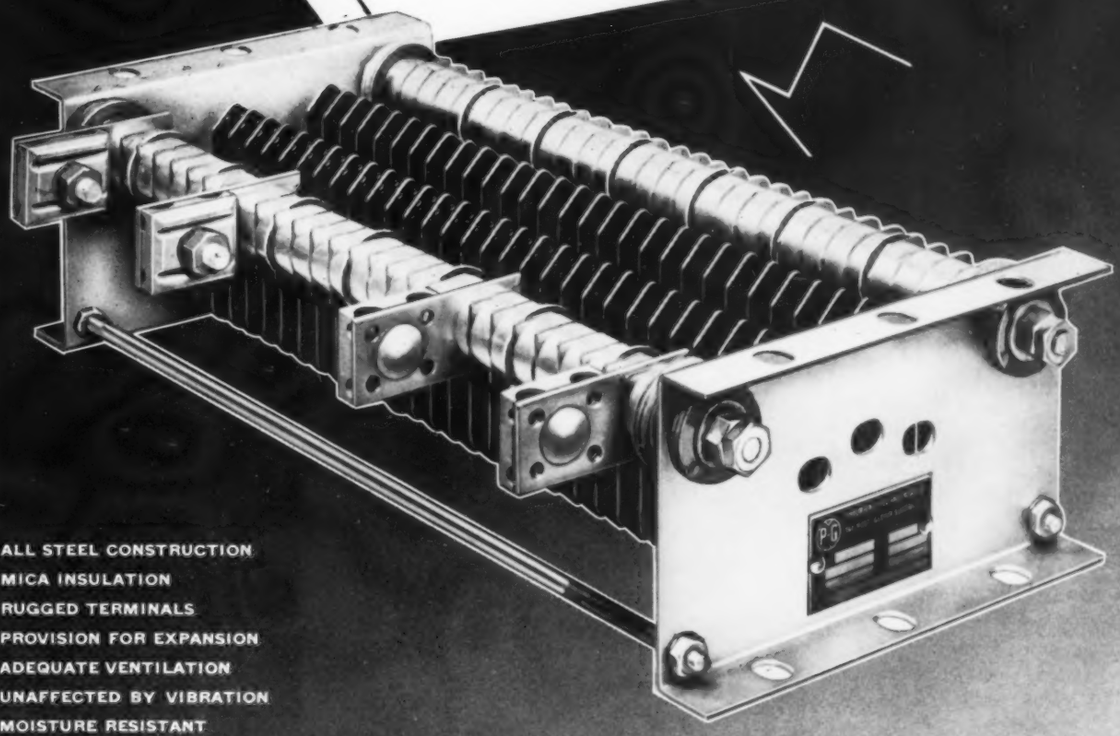

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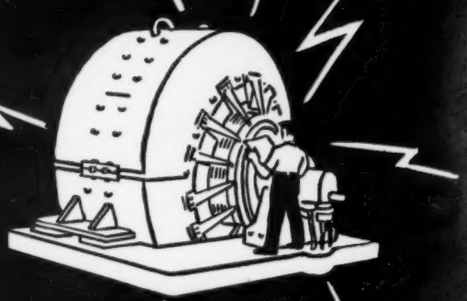

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If brushes spark, machine or brush trouble is indicated. Look for:

1 - Insufficient Spring Pressure.
2 - High Mica.
3 - Oil and dust on commutator.
4 - Brushes off neutral.
5 - Wrong holder adjustment.
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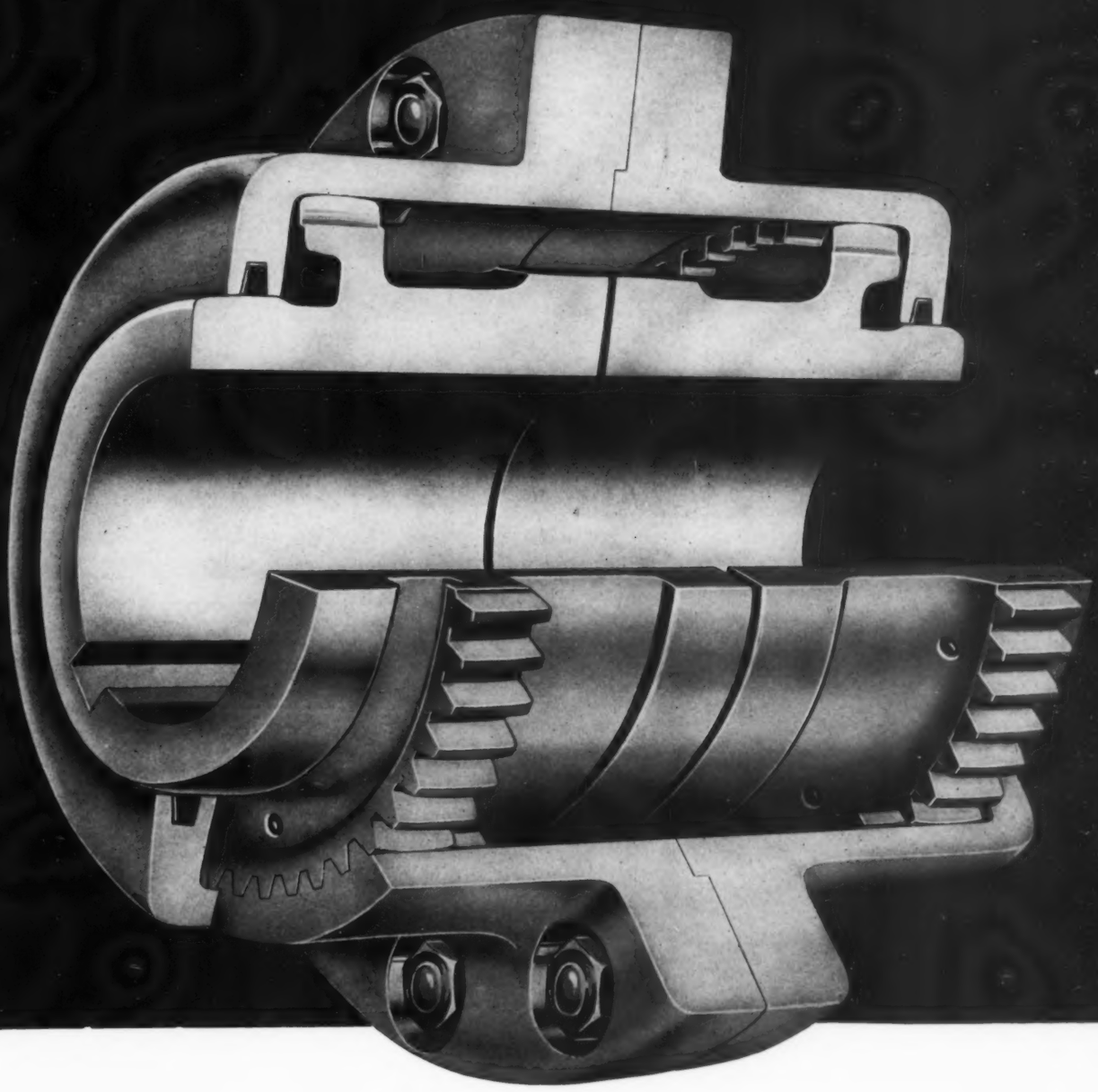

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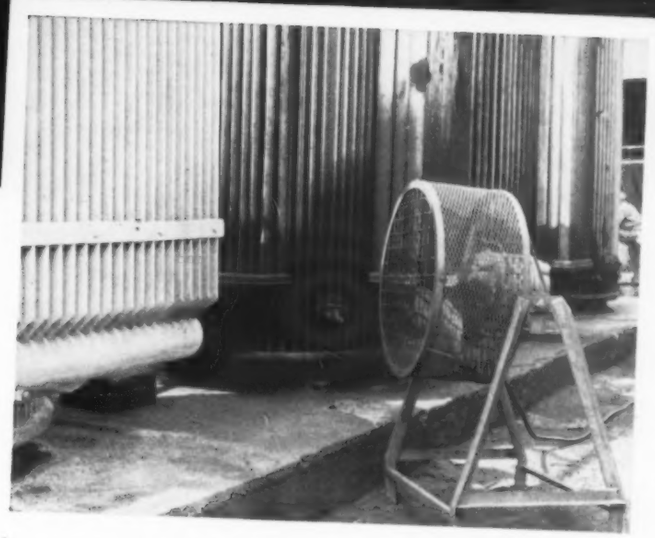

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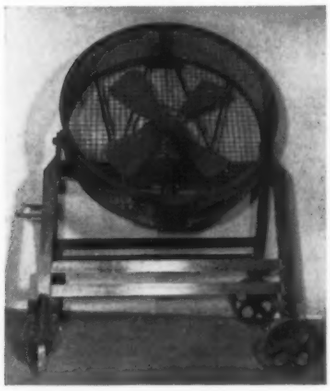

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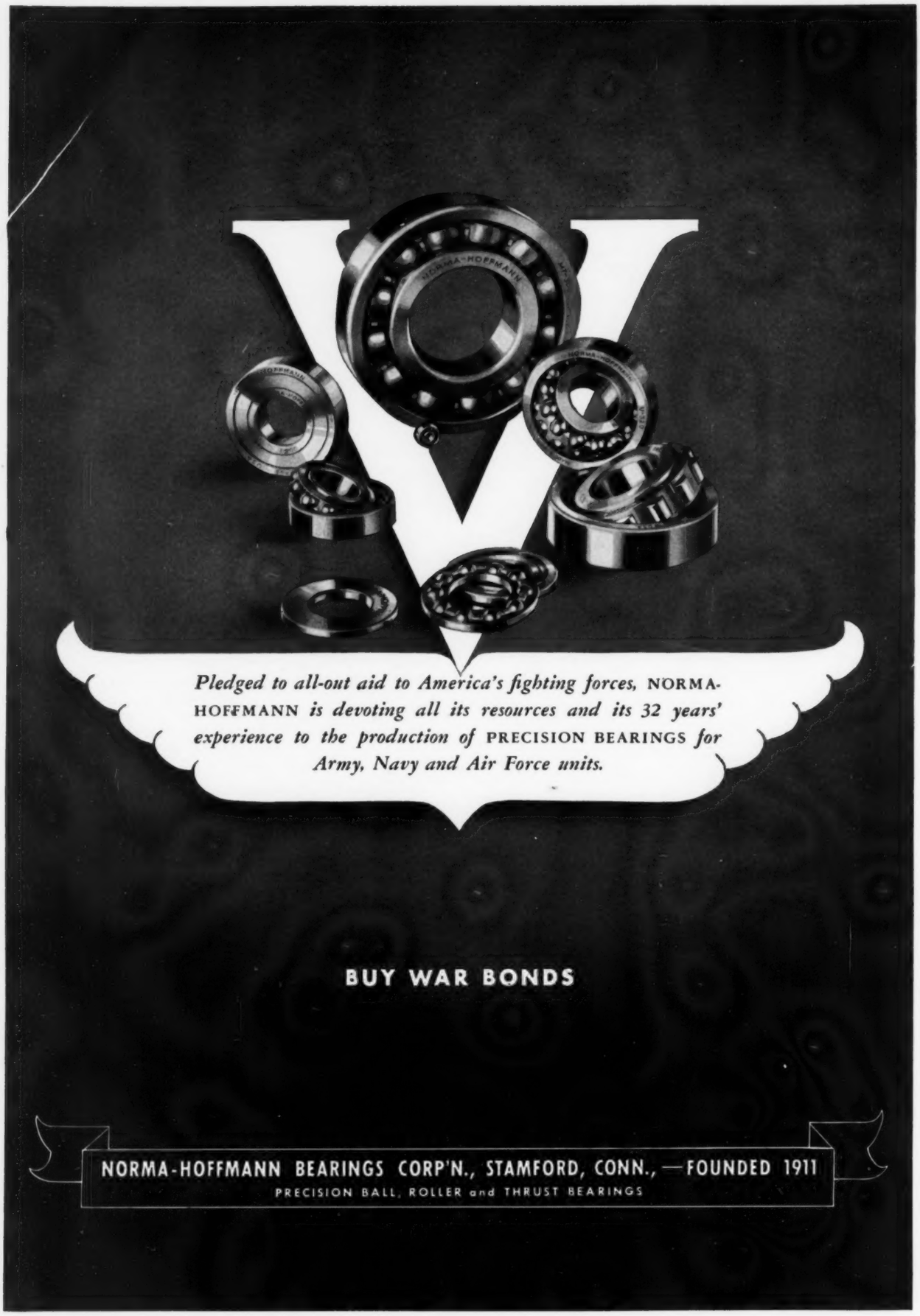
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—a rigid steel structure for strength and alignment.

**FLANGED DOORS**
—formed and welded into sturdy members. Panels at sides, top and back are made the same way.

**GRILLE-TYPE LOUVERS**
—for better ventilation per square inch of opening.

**BONDERIZED STEEL**
—metal treated so that finish withstands severe service without cracking or peeling.

**12 FINISHING OPERATIONS**
—cleaning, spray-priming, then baking; then two sprays and two bakes. Pneumatic sanding prepares for two coats of enamel, both baked.

**SELF-ALIGNING SEPARABLE CONTACTS**
—for dependable service with least loss. No springs in current path; no pigtails.

**ROTARY-TYPE HANDLES**
—for fast safe operation of enclosed circuit breakers.

**CONCEALED HINGES**
—offering 100-degree opening of doors.

it's MULTUMITE

Design and construction features characteristic of Multumite air switchgear are incorporated as standard I-T-E practices.

I-T-E manufacturing is set up to perform all the operations with the skill and speed that standard practices bring with them.

Careful planning of processing and assembly operations enables I-T-E to build air switchgear at the speed required under the pressure of war needs without omitting any of the Multumite features.

I-T-E

## AIR SWITCHGEAR

IMMERSED IN AIR • ENCASED IN STEEL

*Representatives in Principal Cities*

**CIRCUIT BREAKER CO., PHILADELPHIA, PA.**

For arc-furnace control, an amplidyne powers each electrode motor. Each amplidyne is excited by a circuit in which electrode current is balanced against arc voltage. Any unbalance excites the amplidyne, applying voltage to the electrode motor. This voltage, hence motor speed, is directly proportional to the degree of unbalance, insuring smooth and instant operation.

## G-E AMPLIDYNES

### cut melt-down time, save power

NOW, with your present arc furnaces, you can get more tonnage, use less power, and reduce your refractory maintenance by use of the G-E amplidyne—"the short circuit in harness."

Automatic electrode positioning with amplidynes maintains constant power input. Thus melt-down time is held to a safe minimum and outages due to arc breakage or faulty regulator performance disappear. Furnace temperatures are kept within new, narrow limits.

In contrast with former control systems, the amplidyne eliminates contactors, relays, and vibrating parts. Because of the amplidyne's almost instant response, the electrodes follow changing conditions without jogging or overshooting.

***SEND FOR BULLETIN GEA-4053***

A new booklet, "The Short Circuit that Moves Mountains," tells how the amplidyne makes ingenious use of a short circuit, together with load-current compensation. It tells how the amplidyne can, for example, magnify a 1-watt signal from pilot generator, resistance, vacuum tube, or other source into a 10,000-watt output capable of "bossing" the biggest machines.

This booklet gives factual examples of the amplidyne's achievements in improving the performance of cold-strip mills, flow-brightening lines, flying shears, and a wide variety of other equipment. Also available is a special bulletin, "G-E Amplidyne Control for Arc Furnaces," GEA-4104. Ask the G-E office near you for your copies. *General Electric, Schenectady, N. Y.*

AMPLIDYNES

**GENERAL ELECTRIC**

750-207-8456